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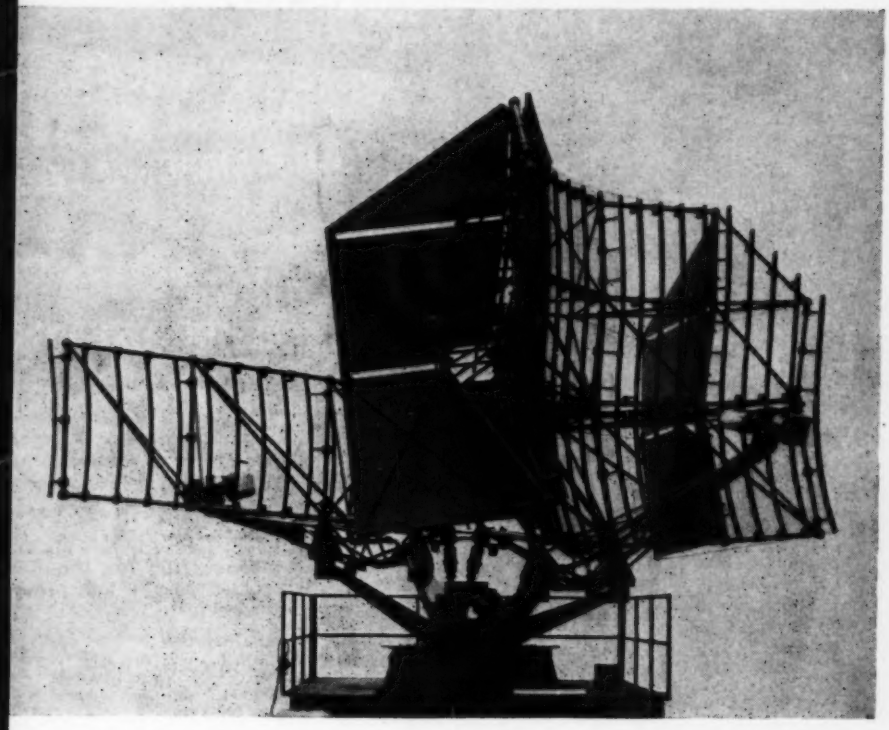

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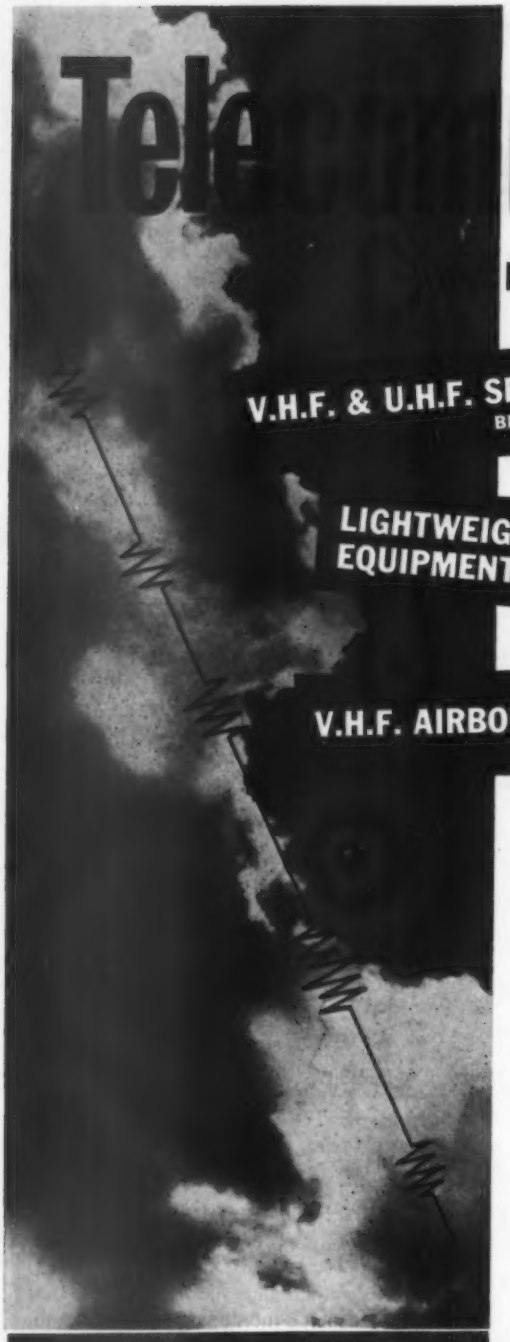

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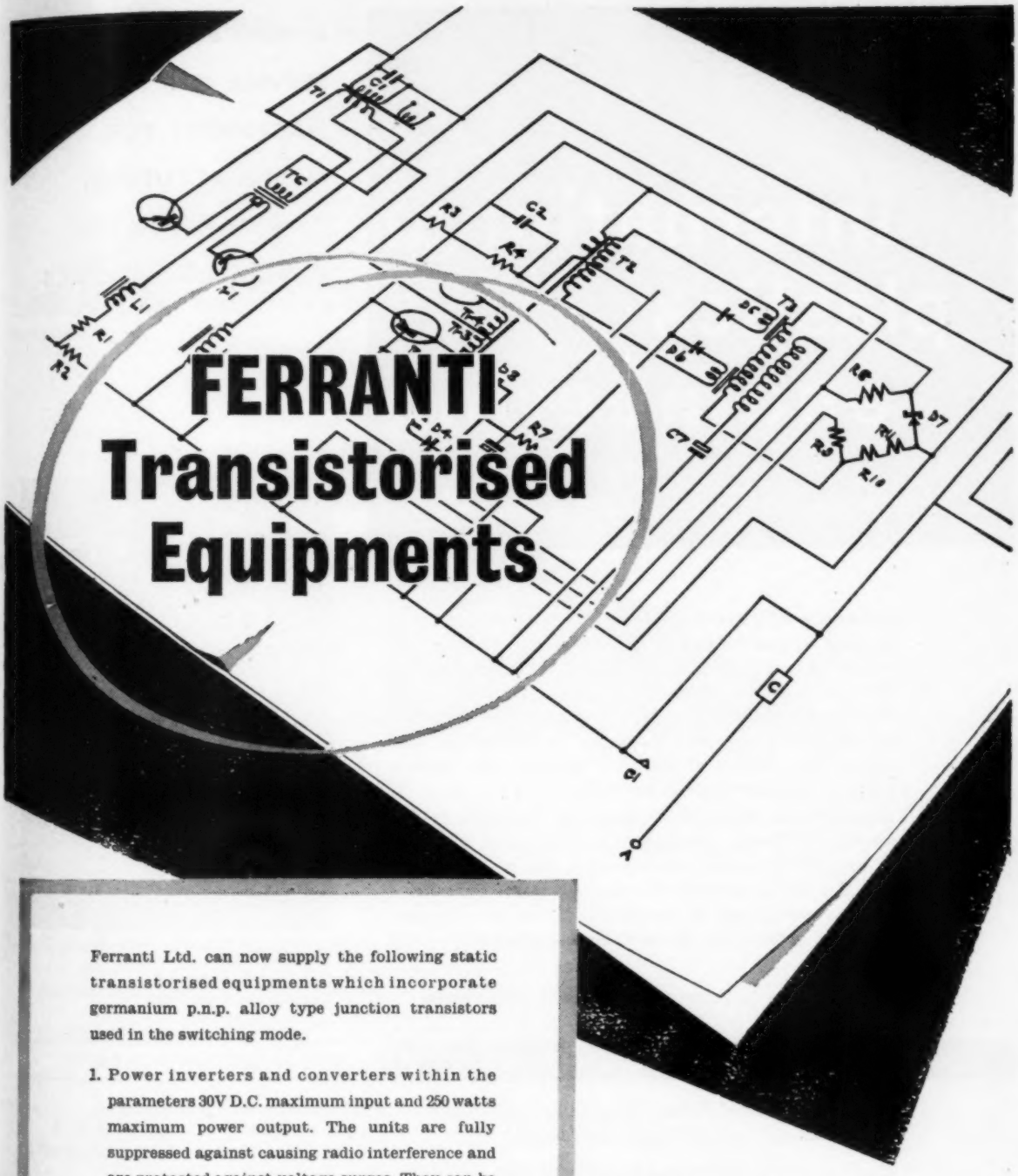

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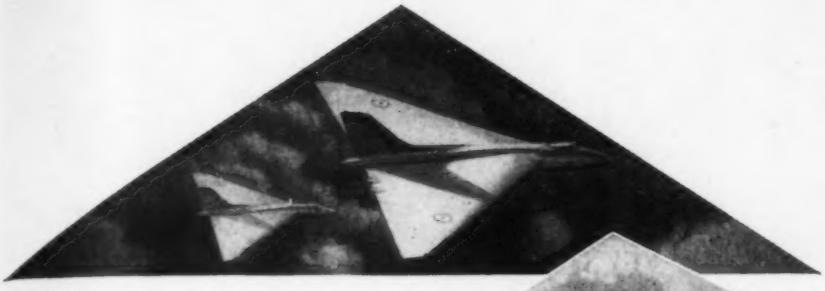

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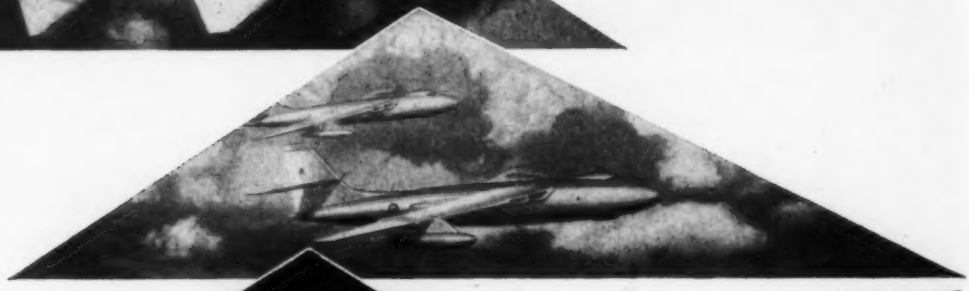

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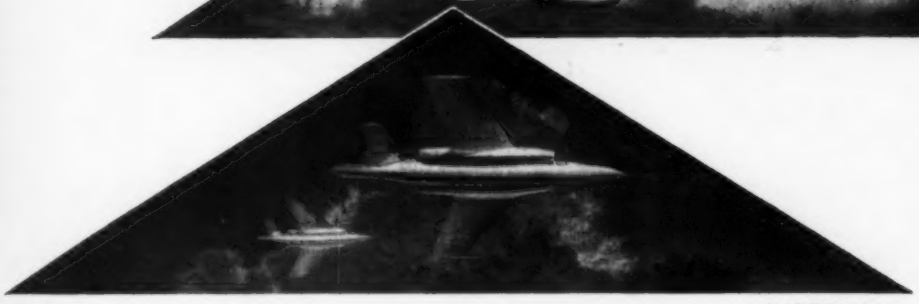

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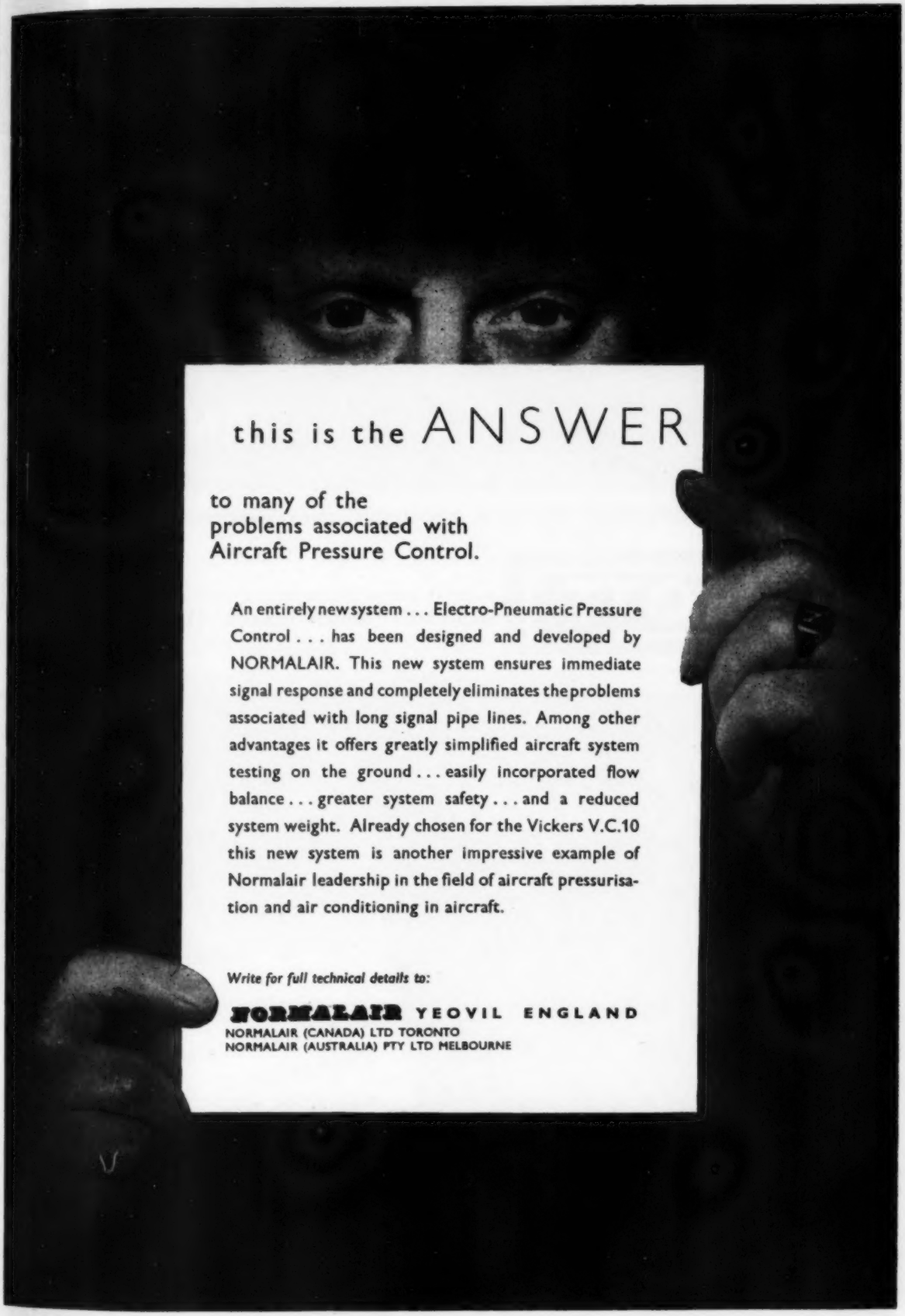
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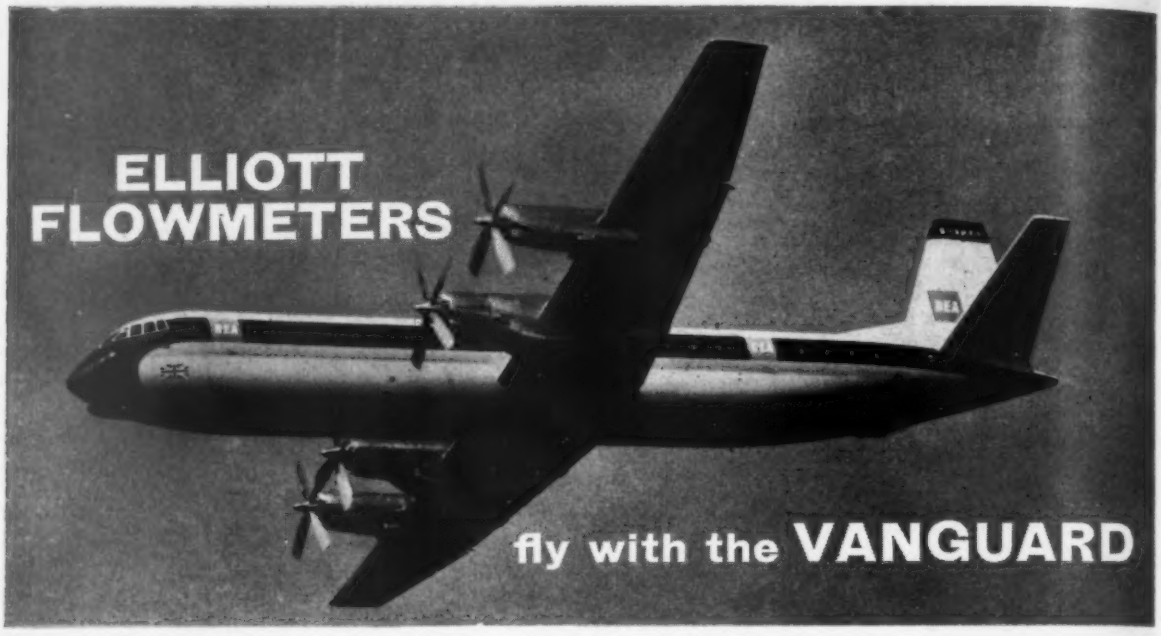

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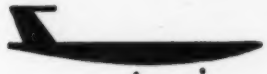

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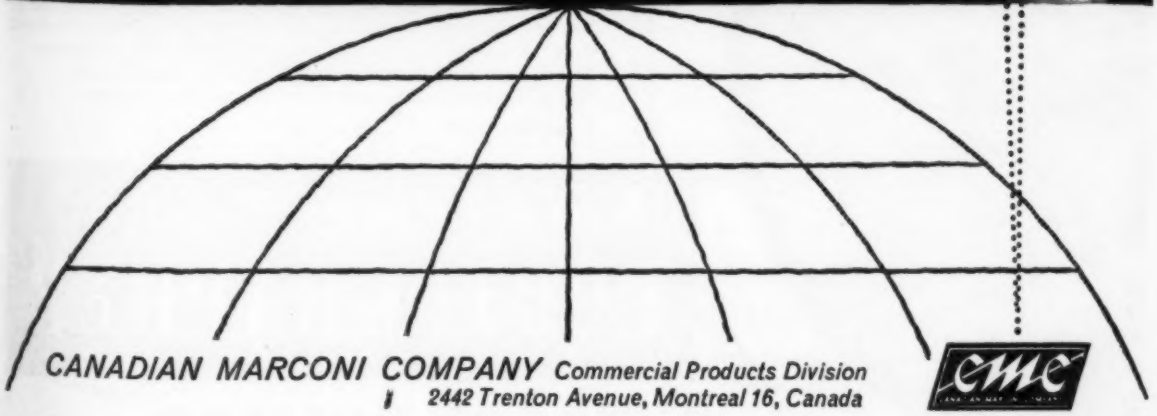

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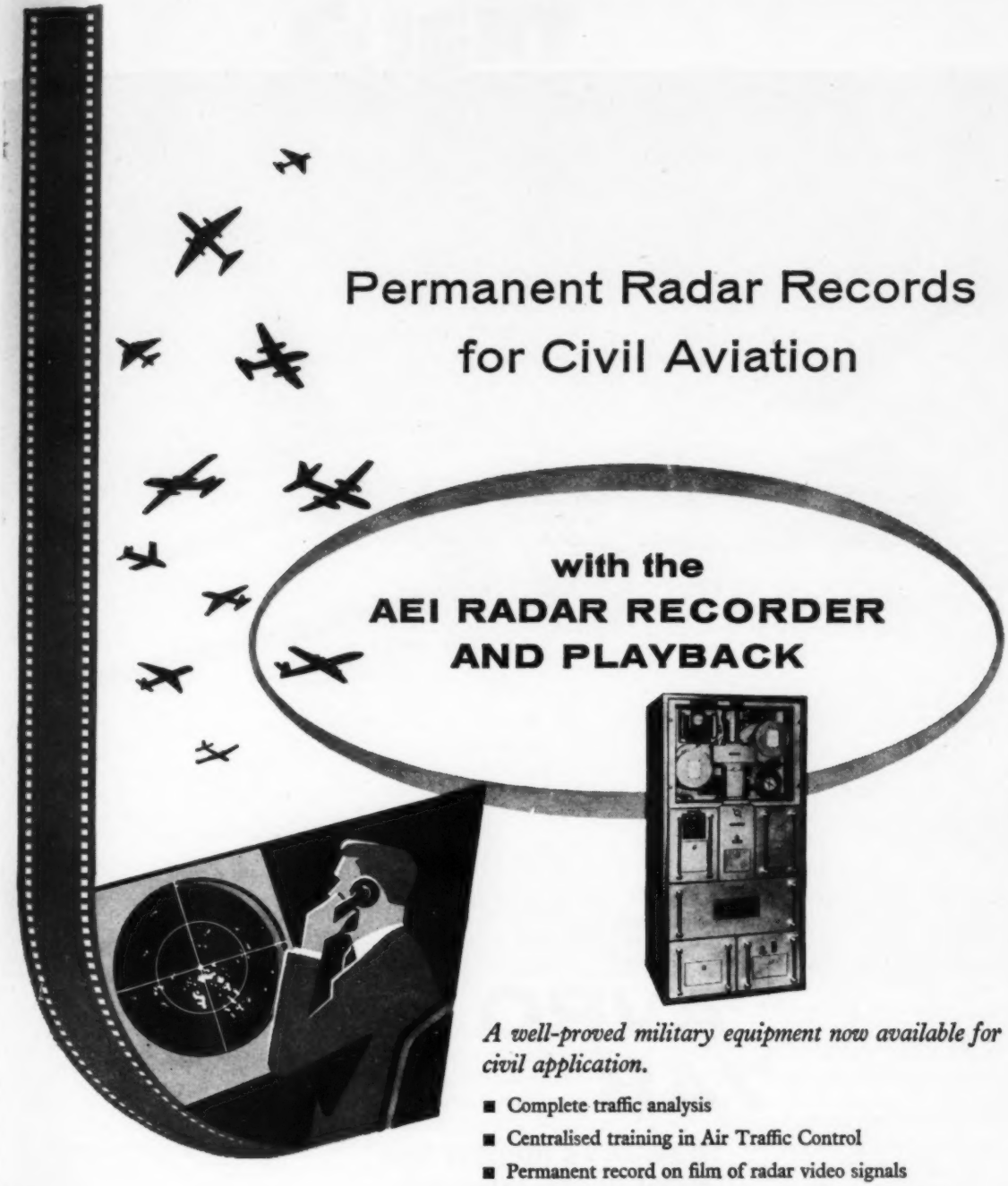

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IN THIS ISSUE

From All Quarters 228
Services Estimates 229
Lightning Squadron 230
Missiles and Spaceflight 232
Olympian Heights 233
Flight System Survey (special feature) 237
Service Aviation 255
Air Commerce 256
Straight and Level 261
Sport and Business 262
Correspondence 264

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The Next Decade

IN ten years time the world is likely to be a very different place. The rising power of China is in itself a factor that has called for three references in the first five paragraphs of this year's *Report on Defence.* Yet in a technical, as distinct from a political, sense this document represents—as one national newspaper has termed it—"Defence as Before." A similar label may well be applied to successive editions over the next ten years. "We expect that our main contribution to the Western deterrent over the next decade will be provided by weapons carried in aircraft," declares the Minister of Defence—a declaration that may be construed as a shade complacent when it is considered that the entire revolutionary and colossal Polaris weapon system was conceived, developed and deployed in something like four years. Yet time, and the introduction of progressively more effective stand-off weapons, may yet vindicate the Minister's view, lengthy though it is.

The Navy, too, is looking some ten years ahead. An improved version of the Seaslug guided weapon is being developed, states the First Lord of the Admiralty, "with even greater range and speed to deal with the types of aircraft likely to be encountered during the latter part of this decade."

It might reasonably be asked whether, after the elapse of so many years, manned aircraft of any type at all will be menacing the Royal Navy; yet the prudence of developing the existing and effective weapon which is Seaslug is not lightly to be questioned in present circumstances.

Meanwhile, the Samos 2 military reconnaissance satellite is already in orbit. Ten years hence its successors may be looking in on a very different picture of world armaments from that envisaged in *Report on Defence 1961.*

2 + 2 Still Makes 4

A HELICOPTER without stabilization or rotor-speed control is a fascinating creature to fly: all the time, at any speed, it wants to wander and diverge. At the hover the pilot is juggling engine power, collective-pitch and yaw pedals, and he has a number of trapping performance limits to avoid. Many an engaging hour can be whiled away learning and then practising the art, and there is a special sense of achievement when it all works out right. After a time it becomes second nature, like riding a horse or a motor cycle.

But in cloud a helicopter with conventional instruments becomes a different creature again. It is difficult and tiring to fly at ideal speed and well-nigh impossible at any other speed; and conventional fixed-wing director instruments do not really help. It is necessary to start to solve the blind-flying problem on a clean sheet of paper. The control requirements are different; stabilization must be provided—either as an automatic system or through the instruments; and five factors must be controlled—pitch, roll and yaw attitude, vertical movement (collective pitch) and transmission speed or power. New radio aids are also needed.

But to be noted down on that clean sheet of paper is a mass of experience in electronics and control technique. Once is has been decided that the answer must be four, two and two will make it in the same old way, even though it has to be written backwards or in italics. It is a question of deciding just what the pilots and the operators need and by which combination of equipment they wish to obtain it.

The special review of helicopter all-weather operation, which begins on page 237, serves to illustrate this point. British companies, together with BEA and MoA, have done excellent development work. The pity is that no multi-engined civil helicopter is available in Britain for commencing operational trials —still less an actual poor-weather passenger service.

FROM ALL QUARTERS

Avon-Mirage Flies

THE Rolls-Royce Avon engined Mirage III had an auspicious introduction at Dassault's airfield at Melun-Villaroche on February 13, when it made its first flight three weeks ahead of schedule. On the 13th and 14th it made four flights in all, and attained speeds in excess of M2.

Powerplant of this Mirage III is the Avon RB.146, which has a sea-level dry thrust of 12,500lb, augmented by reheat to 16,000lb. Rolls-Royce state that "further reheat development, giving significantly increased performance at altitude, is also being evaluated."

The Mirage III is to equip certain units of the RAAF, and an Australian team is now in France in readiness to assess its handling capabilities with the RB.146.

British Bullpup?

ONE of the most plausible rumours currently circulating is that claiming that the Royal Navy is shopping for the US Navy's Bullpup air-to-surface missile. It is no secret that both the RN and RAF have for many months been looking at this Martin missile, and at similar devices developed by Nord-Aviation in France. On February 20 the London *Daily Express* stated that Bullpup is wanted for Sea Vixens and Scimitars, and such a weapon fills an obvious gap in the range of stores which these machines can carry. The original ASM-N-7, and its improved USAF counterpart GAM-83A, are very well established in service; the much improved GAM-83B was illustrated in our December 23 issue.

BEAGLE-Miles Board

FINANCIAL and other arrangements whereby the aviation business of F. G. Miles Ltd becomes "an important component of the BEAGLE Group" have been completed, the group now comprising British Executive and General Aviation Ltd and its two subsidiaries, BEAGLE-Miles Aircraft Ltd at Shoreham and BEAGLE-Auster Aircraft Ltd at Rearsby.

Membership of the BEAGLE-Miles board is as follows: Messrs Peter G. Masefield, chairman; F. G. Miles, deputy chairman; G. H. Miles, technical director and chief engineer (with responsibility in these spheres throughout the group); J. W. P. Angell, general manager; L. Blount (Pressed Steel Co), director; and Mrs O. M. Wadlow, financial director.

Discoverer Comes of Age

THE 20th and 21st launchings in the USAF Discoverer satellite programme were made on February 16 and 18 from Vandenberg Air Force Base, California. The latter launch included the first restart of the powerplant of an Agena B stage while in orbit.

Discoverer 20 was described as "the biggest and heaviest rocket of the series," and its Thor-Agena launch vehicle was reported to be "an improved model." Test equipment for other satellite programmes was carried in the instrument capsule, which it was hoped to recover on February 21.

The Agena engine of Discoverer 21 was restarted on February 18 on command from Vandenberg, and this feat was described by an Air Force spokesman as an achievement promising the future conversion of passive observation satellites into manœuvrable military spacecraft. The satellite weighed 2,100lb and was in an initial orbit varying from 155 miles to 670 miles. It was carrying instruments to measure heat radiation from the Earth and test missile defence alarm equipment for future Midas satellites.

Mysterious Magisters

THREE Fouga Magister trainers were delivered to Elisabethville, Katanga, on Thursday of last week, reportedly in a Stratocruiser of Seven Seas Airlines which had flown in from Toulouse. The aircraft, it was thought, either formed part of a Belgian order placed under NATO auspices, or of an order for nine placed by President Tshombe of Katanga.

Tiger Afloat?

THE newly formed Seaplane Club has been offered a Tiger Moth free of charge, provided the club can acquire a pair of floats for the aircraft. The founder of the club, Air Cdre G. J. C. Paul, secretary-general of the Air League, believes that there must be suitable floats in existence somewhere in this country, and would be grateful for any assistance in locating them. Information should be sent to the air commodore at Londonderry House, 19 Park Lane, London W1. [Perhaps the Royal Navy might weigh in with a set of Queen Bee floats?—Ed.]

SERVICE LIAISON between Avro and the RAF is the task of Gp Capt A. K. Hunter, OBE, BSc (Eng), AMIMechE, AFRAeS, DCAe, RAF (ret), whose appointment as the company's Service liaison officer has just been announced. Trained as a fighter pilot, he transferred to the RAF Technical Branch on its formation in 1940 and remained in it until his retirement. He was at Bomber Command headquarters when the Avro Vulcan was being introduced into service

IN BRIEF

The prototype Victa R-2 four-seat light aircraft made its first flight on February 16 at Schofield Aerodrome, near Sydney, piloted by Flt Lt R. Green, who is chief test pilot at the Richmond RAAF station.

Mr P. J. Daglish, who joined D. Napier & Son Ltd last September as a special executive, has been appointed to the board as commercial director.

Overseas orders placed with the French aircraft industry during last year amounted to more than NFr 1,142m (nearly £83m), more than double the 1959 figures.

United Aircraft Corporation are to change the name of their wholly owned subsidiary, United Aircraft Export Corporation, to United Aircraft International Inc from March 1.

Link Luckett, who last May rescued two climbers by landing a Hiller 12E at 18,000ft on Mt. McKinley, Alaska, has been awarded the Carnegie Silver Medal for heroism.

Potez Air Fouga and Heinkel are jointly to develop to official German order the CM.191 four-seat version of the Magister (with Marboré VIs) for military and civil purposes. It will cruise at 435 m.p.h. for 935 miles with 880lb payload. A prototype will be at the Paris Salon.

Donald Douglas Jr, president of Douglas Aircraft, said in New York recently that the future strength of the US aircraft industry might depend on "closer co-operation or outright mergers." Noting that the trend "had already been set by the British aircraft industry," Mr Douglas said that such consolidations would be chiefly the result of the tremendous costs involved in producing future aircraft. Leaders of the industry agreed that the development of a supersonic airliner was "beyond the capabilities of any single company."

SEA RAIDERS: Mentioned in the Navy Estimates (see opposite page) is the fact that a Buccaneer Intensive Flying Trials Unit is to be formed before midsummer. This photograph is the first to be released of the Buccaneer production line at the Blackburn works at Brough

SIKORSKY S-61D twin turbine, boat-hull helicopter for which an option-to-build has been granted to Weser Flugzeugbau G.m.b.H., of Bremen. There are rear-loading facilities as in the HR3S of the US Marine Corps; engines would probably be D.H. Gnomes

Lockheed Aircraft Corporation announces the appointment of Mr Richard L. Bean, formerly public relations director of the California Division, as manager of the New York office. He succeeds Mr Erik Nelson, who becomes corporate regional director for Canada.

Among those attending the 1961 Helicopter Association of America convention, held recently at Haddonfield, NJ, were Mr Colin Cooper and Mr I. A. F. Donnelly of Helicopter Sales Ltd, British sales representatives for Hiller Aircraft.

Mr Frederick Delves, who in 1956 left the technical staff of Handley Page to join the Georgia division of Lockheed Aircraft, was recently named "Management Man-of-the-Year" by the 2,100-member Lockheed management club, one of the largest organizations of its kind in the US.

Referring to the article "Dunlop's Aviation Jubilee" (February 3), Dunlop Aviation Division ask us to make it clear that the mainwheels of the Beardmore Inflexible of 1928 were manufactured by them to the designs of Mr W. S. Shackleton, who was Beardmore's chief designer at that time; he is now, of course, president of W. S. Shackleton (Aviation) Ltd.

On April 10-11 Loughborough College of Technology is to hold a symposium on the applications of analogue computers. Details from Dr H. Buckingham, College of Technology, Loughborough, Leics.

Next Monday, February 27, Aerocontacts Ltd and their associated companies will sever their 14-year-old connection with Gatwick Airport by moving to larger premises at Gatwick House, two miles distant (Mr H. K. Hughes, DFC, the managing director, has chosen the name in order to perpetuate his own 22-year association with the airport, which was a fighter station during the war). The new telephone number is Horley 4455, and Telex service (8716) has been installed.

ESTIMATING FOR DEFENCE

FOUR significant documents have been made public by the Government. Appearing within a few days of one another, as is customary each year, they are the Report on Defence, and the Navy, Army and Air Force Estimates. Points of aviation interest from the first-named, and from the Ministerial memoranda accompanying the others, are summarized below.

Report on Defence 1961: Britain's present contribution to the strategic nuclear deterrent is the V-bomber force, equipped with British free-falling nuclear bombs. The force has the capacity to penetrate to its assigned targets, and its retaliatory capacity and efficiency are being constantly increased by wider dispersal and shorter reaction time. It is expected that our main contribution to the Western deterrent over the next decade will be provided by weapons carried in aircraft. To counter probable improvements in fighter and missile defences the Mk 2 V-bombers will be given an increasing stand-off capability over this period. The missiles which carry the British-made warhead must be of such type and characteristics as will present the greatest diversity of attack. From British and American sources it is hoped to provide a combination of methods. New types of aircraft for tactical and strategic roles will be able to make their attacks at very low levels. Britain already contributes Valiants and Canberras to NATO tactical forces.

Navy Estimates 1961-1962, list four aircraft carriers as being in the operational fleet or preparing for service with it. They are HM Ships *Ark Royal, Hermes, Victorious* and *Centaur*. HMS *Bulwark* is listed as a commando carrier. Of the four first-mentioned vessels three will normally be operational throughout the year and a fourth will be refitting. Tenders will be invited for two more guided-missile destroyers. Four are already under construction. These ships are being armed with the Seaslug and Seacat anti-aircraft missiles and with 4.5in guns. They will be thoroughly adaptable Fleet units with a good surface gunnery and bombardment capability, the latest submarine detecting devices, and anti-submarine weapons which will include a Wessex helicopter. The first of the class, HMS *Devonshire*, should complete by the spring of 1962.

A new system for the handling of information and the control of weapons has been developed and will be incorporated in HMS *Eagle* during her present modernization. It makes full use of the latest techniques in automation and will greatly increase the speed and accuracy of the ship's target handling.

Trial firings of Seaslug during 1960 have proved it to be extremely effective. An improved Mk 2 version is being developed with even greater range and speed to deal with aircraft likely to be encountered during the latter part of this decade. This version will be fitted in the two guided missile destroyers soon to be ordered. Seacat has been ship-fitted for sea trials, and firings of fully guided missiles against drone targets have started. An Intensive Flying Trials Unit for the Buccaneer will be formed before mid-summer this year to carry out service trials. The first operational squadron is expected to form next year.

The Wessex anti-submarine helicopter is still undergoing trials and development, but it is planned that the first front-line squadron will be embarked in HMS *Ark Royal* in the autumn of 1961. A modified version is being considered to lift Royal Marine commandos from the commando carriers. Its superior load-carrying capacity would greatly increase the effectiveness of these ships. The Westland P.531 is a light torpedo-carrying helicopter with which it is planned to arm new Leander and Tribal Class frigates. Operating helicopters from frigates will greatly increase the speed and range of attack from the frigate and represents a major advance in anti-submarine warfare. Production has started in this country of an American-designed lightweight anti-submarine torpedo of greatly improved performance, for use by helicopters. This weapon is a significant advance on the air-dropped torpedoes at present in use, being lighter and faster to the target.

Army Estimates 1961-1962: Deployment of Honest John in the Rhine Army is to be completed, making three composite regiments of missiles and 8in howitzers. New surveillance drones are to come into service in the Rhine Army for target acquisition. The experiment of air trooping to Germany has been successful, and by October there is to be a complete change-over to it on this route. The Army is investigating "air-supported vehicles to increase mobility." Reference is made to "a small number [given in *Flight* for January 27 as 12] of Alouette helicopters" coming into service.

Air Estimates 1961-62: Handling and maintenance trials of Blue Steel under service conditions are due to begin in the coming year. Subject to the successful completion of the development programme it is planned to introduce Skybolt in the mid-1960s. Production weapons will be bought outright, will be carried by the Vulcan, and will be fitted with British warheads. The Vulcan 2 armed with Skybolt will no longer have to penetrate enemy air defences to attack. Since the reaction time was demonstrated at Farnborough last September shorter times have been achieved. The current level of expenditure on the deterrent, inclusive of the capital and running costs of the V-bomber force, its airfields, nuclear weapons and research and development, together with the running costs of Thor, represents about 10 per cent of the defence budget.

Orders have been placed for a Lightning Mk 3 which will carry an improved air-to-air weapon. Deployment of Bloodhound 1 in this country will be completed during 1961-62; firings at Aberporth have demonstrated the accuracy of the homing system and high lethality. Orders are being placed for Bloodhound 2, which will have a greatly increased performance and will be air transportable. Work has begun on a new high-performance radar system which will include computers and data handling equipment needed for the interception of supersonic aircraft. This system will also form an integrated civil and military air traffic control organization.

Coastal Command's Shackletons have been fitted with new radar, new navigation equipment and improved submarine plotting facilities. They will be provided with improved communications and better means of locating survivors in the sea.

All Transport Command's Britannias have now been delivered, and the proven value of the Comet has led to the placing of an order for the Comet 4C. During the coming year the Belvedere will enter squadron service and the first deliveries of the gas-turbine-engined Whirlwind are expected. Later on a twin-engined version of the Wessex will be introduced.

In RAF Germany, new navigation equipment is being fitted to improve the capacity of the Canberra tactical atomic strike-force to operate in all weathers. The Swift will shortly be replaced altogether by the Hunter. The Canberra force in Cyprus will be largely re-equipped with later marks of aircraft during the next twelve months. Fighter ground attack squadrons in the Middle East have now been fully re-equipped with the Hunter GA.9. During the coming year the Far East fighter force will be strengthened by the introduction of Javelins and Hunter GA.9s. Belvederes will increase the Command's capacity for tactical support.

The basic flying training schools have now been largely re-equipped with Jet Provosts, and towards the end of the year an improved version of the aircraft, with the more powerful Viper 11 engine, will be introduced. Certain changes are being made in the advanced training programme: after basic training on Provosts pilots will do advanced training on either the Varsity, the Vampire (to be replaced by the Gnat), or on helicopters.

The fatal-accident rate for all Service aircraft was 30 per cent lower in 1960 than in 1959, though 1959 had been the lowest rate previously recorded.

The increase in recent years in the number of air movements, in the speed and performance of modern aircraft and in civil flying at high altitudes, has greatly increased the responsibilities of the air traffic services. The Air Ministry is working closely with the MoA in this matter to ensure safety in flying by military and civil aircraft in the limited air-space of the UK. As the result of a successful experiment last year, RAF radars are providing a service for civil and military aircraft operating above 25,000ft. The service, which is operated by integrated military and civil control teams, is now being extended to cover the greater part of United Kingdom air-space. During 1960 some 35,000 movements of military aircraft across civil airways were made under radar surveillance.

LIGHTNING SQUADRON

ILLUSTRATED WITH "FLIGHT" PHOTOGRAPHS

LAST week the Air Ministry invited *Flight* to RAF Coltishall, north of Norwich, where is based No 74 Sqn, the first in the Service to be equipped with the English Electric Lightning. Ever since the first flight, almost seven years ago, of the first P.1A research aircraft this journal has chronicled the progress towards operational service of one of the fastest and most potent defensive weapon systems yet developed. The Lightning is an exceptional advance on all that has gone before, for Britain cannot afford intermediate stages. A day at Coltishall suggests that this way of doing things can be made to work very well indeed.

All the aircraft so far released are Lightning F.1 all-weather fighters, powered by two Rolls-Royce Avons with reheat, equipped with Ferranti Airpass 1 multi-purpose radar fire-control, and having a standard armament of two de Havilland Firestreak missiles and two Aden 30mm guns.

Although the Lightning is the RAF's first truly supersonic aeroplane, nobody has been hand-picked to fly it. Instead, Hunter squadrons are converting with no change in personnel other than routine postings, and the same will be true when the Lightning begins to replace the Javelin also. Yet it would be idle to deny that conversion is a major task, for not only is the Lightning a very complicated piece of machinery, with a flight performance roughly double that of any previous RAF equipment, but it is also our first single-seat night and all-weather fighter.

While the aircraft was being evaluated by the Air Fighting Development Squadron, pilot-conversion difficulties were being anticipated by the Lightning Conversion Unit, which started when a permanent staff of four pilots, a navigator and a fighter-control officer prepared the ground-instruction programme and the first ten flying exercises (those concerned with pure handling). Moreover, thanks to General Precision Systems, no pilot flies the Lightning until he has had every emergency in the book thrown at him in the simulator. On his first familiarization trips every Lightning pilot is accompanied by a Hunter flown by an instructor; and for the pair to formate at operational height the pupil has to give the chase aircraft a 28,000ft start. Although it is considered desirable for every pilot to have first spent at least six months with an operational squadron, no great experience is required; apart from the flight commanders and their deputies, all 74 Squadron's pilots had joined straight from OCU, and were thus on their first tour.

Combining the functions of pilot and navigator in one man can be accomplished only with the assistance of "black boxes" far surpassing in number and refinement anything previously seen in a British aeroplane of this size. As an inevitable sequel, the servicing personnel are almost twice as numerous as they were in Hunter days. They are divided into a small line crew, and three servicing teams, each under a Ch Tech and embracing all the trades required for the progressive servicing undertaken at the station. Each team is personally responsible for one-third of the squadron's aircraft, and the name of the "crew chief" is stencilled, American fashion, on the nose of each machine, immediately below that of its pilot. Even an aeroplane like the Lightning can exhibit individual foibles, and this personal approach seems to pay dividends.

To fly a Lightning one has to dress for the part—and this is a far longer job than getting into the aircraft. Present rig is a standard "bonedome" and P-type mask, g-suit and pressure jerkin; or, in winter, a pressure jerkin and immersion suit. Eventually, however, partial-pressure suits will be worn, together with a pressure helmet (Baxter Woodhouse & Taylor); even in winter it is doubtful if pilots could wear this for protracted periods.

Walking out to the aircraft one is impressed by its pugnacious bulk, and by the fact that it is possible to pass beneath the wing without stooping. A boot-cleaning brush adorns each side of the lofty ladder leading up to the cockpit, and external controls are provided for opening the massive clamshell canopy. As in the Javelin FAW.8 and 9, the ejection seat (Martin-Baker Mk4BS) incorporates a combined harness, and seat height is electrically adjustable. The cockpit is snug, but by no means cramped, even for the tallest pilot.

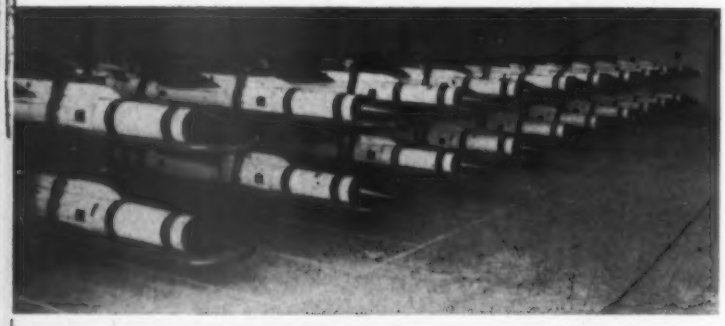
Instrumentation incorporates several new faces, but the ultimate OR.946 panel has not yet been achieved. Directly in front of the pilot's eyes is the Pilot Attack Sight, immediately to the right of which is the AI radar display. To the left is an attention light,

The dicing of 74 Sqn consists of black and yellow triangles arranged as above; black Firestreaks are inert drill rounds

The Baxter Woodhouse & Taylor pressure helmet (right) has to be individually tailored

Half of the two-score Firestreaks in the ready-for-use store are visible below. Aerodynamic surfaces are protected by black fibre gloves, and the seeker head and fuzing windows by red plastic or rubber covers

The CO, Sqn Ldr Howe, is on the extreme right of the informal group photograph



Five of 74 Squadron's Lightning F.1s show that they have already learnt to fly a good echelon to starboard

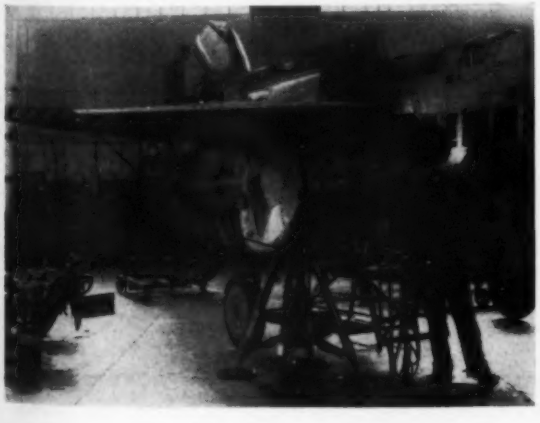
which flashes when any of the red windows of the central warning panel illuminate (a loud fire-engine bell is also heard in the pilot's earphones). Upper and lower engines are controlled by matched power levers of curious form, immediately behind which are the weapon control panels and the miniature control column for the radar fire-control. The autopilot controller is to starboard, for the right hand.

In emergency, aircraft would be parked on the operational readiness platform at the end of the runway. Depending on the readiness state, pilots may be in their cockpits and all the aircraft systems warmed-up for action. Vernons Industries supply GPUs which feed electric power to ease the load on the internal batteries. The only other ground connection is the Telebriefing lead providing land-line contact with the operations room.

On receipt of a call to scramble—a brief but very informative message—both Avons are started together by their Plessey Avpin (iso-propyl nitrate) starters, and it is possible to get the aircraft rolling within a few seconds. All take-offs are dry (i.e. without reheat), although if an engine were to fail during take-off—something which has yet to happen—both power levers would be pushed forward into reheat to give all the thrust required. At take-off r.p.m. the nozzles are closed, to give maximum dry thrust —considerably more than twice the urge of a Hunter. One point that must be watched is that the aircraft must be lifted off the ground the moment the appropriate speed is reached, otherwise there is a risk that the tyres might throw their treads.

Less than 30sec from the scramble order having been received, the wheels are retracted, the aircraft has turned hard to port or starboard and reached about 450kt. The general idea is then to climb to operational height as soon as possible, and at M0.9 and something less than 100 per cent cold power it is possible to reach operating height in about 3min. At 100 per cent cold power the angle of climb at M0.9 becomes too much for convenience,

Notwithstanding the Lightning's complexity, the servicing crews keep aircraft in this condition only for brief periods



and reheat is never employed below the tropopause (about 36,000ft).

At greater heights four stages of reheat are available, each matched to a different nozzle area. Maximum power produces quick acceleration to a Mach number greater than 2, and high-altitude manoeuvrability is such that, in the words of Sqn Ldr John F. G. Howe, 74's South African CO, "We know we can outfight any fighter equivalent to the USAF Century series." All controls are fully powered, each engine energizing an independent hydraulic circuit. Partly for this reason it is not normal practice to shut down either engine in the air, although practice relights up to extreme altitudes have given no trouble.

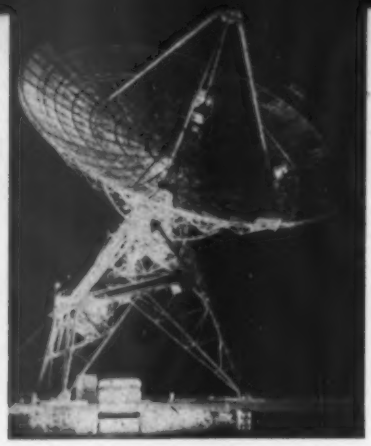
Operational employment of the Lightning may not be described in detail, but much can be surmised. The initial climb is made on a designated heading, and the radar is operating before take-off. The target-locating, lock-on and other functions of Airpass have already been described at length in this journal, and so has the Firestreak missile which forms the Lightning's primary armament. Although the standard armament is two missiles and two guns, the Lightning F.1 can carry two guns and 48 2in rockets, or four guns; and doubtless later Marks will introduce further variations.

In normal cruising flight the nozzle area is again adjusted to the position giving minimum specific consumption, and Coltishall Lightnings have remained airborne for more than an hour and a half. The let-down and landing are perfectly straightforward, and completely automatic descents are possible. Approach speed can be held within 1kt; this makes formation landings of pairs of aircraft practicable, and on such occasions the No 2 calls "stream" to ensure that the leader does not deploy his braking parachute first. The drag chute is employed on all landings, and for many months has achieved reliability of virtually 100 per cent. Brakes (Dunlop, with Maxaret) are not used in a normal landing, and a 1,500yd runway is theoretically adequate provided the drag chute can be relied upon. In fact, English Electric have demonstrated that the Lightning can stop in 800yd; but if this were common practice the RAF would get through vast quantities of brake pads and tyres. Coltishall's runway is 2,500yd, and there are five 3,000yd runways in the vicinity.

Although 74 Sqn pilots occasionally do cross-countries, usually overflying Scotland and Wales, practically all operational exercises are flown over the North Sea, where supersonic bangs are admissible. Since the Lightning's primary rôle is bomber destruction, it operates as a single aircraft, much like the Javelin.

First delivery to 74 Sqn was made last July, and today the entire squadron has reached a satisfactory degree of operational effectiveness. The unit has operated its Lightnings under all weather conditions both by day and night, and has carried out every interception procedure short of firing missiles. Lightning squadrons, which now include 54 and "Treble One," are each ultimately to receive at least one two-seat T.4 for all dual checks and demonstrations. These side-by-side machines have the same performance and equipment as the F.1, and will first be delivered to the Lightning Conversion Unit in about two months' time. It is perhaps appropriate to conclude with another quotation from Sqn Ldr Howe: "The performance of the aircraft, coupled with the ease with which it is flown, gives the pilots confidence, and the fact that it is felt to be the best fighter in operational service in the world today gives our Lightning pilot the highest possible morale."

Missiles and Spaceflight



This 85ft diameter reflector aerial at Woomera, part of the NASA deep space station at the Australian range, was used in the US Moon-bounce transmissions of February 11 (see news item at foot of page 236)

VENUS PROBE HEADING FOR NEAR-MISS?

Official Soviet reports last week stated that the space probe launched on February 12 was continuing along its path to Venus "on a trajectory near to the calculated one." A maximum miss-distance from the planet was quoted on the assumption that no mid-course corrections were made, but it was not specified whether such corrections were in fact to be attempted.

On February 13 Tass reported the following progress:—

The automatic interplanetary station is continuing its flight along the set course. By noon Moscow time on February 13, 1961, the station had receded from the Earth to a distance of 488,900km (303,750 miles) and was above the point with the geographical co-ordinates of 0° 53′ North and 88° 2′ East. The station was in the area of the sky between the constellations of Cetus and Pisces, in the centre of the triangle formed by the constellations of Beta Aries, Alpha Pegasus and Beta Cetus.

The measurements of the trajectory which have been carried out have demonstrated that the heavy artificial satellite was placed into the planned round-the-Earth orbit with great accuracy; the cosmic rocket which took off from the satellite ensured the accurate placing of the automatic interplanetary station on a course towards Venus.

The flight velocity of the automatic station when first put on the Venus-bound course exceeded the second escape velocity. As it moves forward, the velocity of the interplanetary station decreases as a result of the action of the Earth's pull. By noon on February 13 the station was moving away from the Earth at a speed of 4.05km per sec (9,050 m.p.h.). After a few days the automatic interplanetary station will be out of the so-called sphere of terrestrial gravitation, moving at just under 4km per sec (8,950 m.p.h.).

The scientific equipment on board the automatic interplanetary station is designed for studies of cosmic radiation, magnetic fields, interplanetary matter and for registering collisions with micrometeorites. A temperature control system ensures the proper conditions for the operation of the equipment on board the interplanetary station.

The station carries radio equipment designed to accomplish the following tasks: to measure the parameters of the station's movement in relation to the Earth; to relay to the Earth the results of the measurements carried out by the scientific instrumentation on board; and to relay to the Earth information on the operation of systems and units on board.

During the playback sessions the instrument package is fed by chemical power sources which are constantly charged during the flight from solar batteries. The constant lighting of the solar batteries, to obtain maximum energy from them, is done by means of a solar orientation system.

Two playback sessions have been triggered off since the start of the automatic interplanetary station. Trajectorial measurements were taken during these sessions and a large volume of radio-telemetric information was received.

According to data received at the measuring centre, all systems on board the automatic interplanetary station operated as planned. During the last transmission period the temperature aboard the station was 20°C above zero. The solar batteries were oriented correctly with regard to the Sun and generated the required current. Processing of telemetric information obtained is continuing.

Communications with the automatic interplanetary station will be maintained once every five days. Reports on the further movement of the station and the results of measurements will be issued once a week.

Prof V. Dobronravov commented on the same day that the successful launching of an automatic station towards Venus had marked the beginning of the systematic application of a new method in space exploration—the use of automatic interplanetary stations fitted with radio-telemetric systems for communicating with the home planet and playing back the results of space observations. Extensive calculation had been carried out to compute the movement equation, taking into account all the factors influencing the flight, such as the gravity of the Sun, Earth and other planets. The drawn-up equations had to be solved numerically, and the Soviet rapid-action electronic computers undoubtedly played a great part in this work.

The accurate placing of the automatic station on the required flight trajectory towards the planet was an exceptionally difficult technical problem, the professor said. The automatic station started off from aboard a heavy sputnik launched into outer space by a specially improved powerful multi-stage rocket. Many factors complicated the placing of the station on this trajectory. The station had to be given a speed of not less than 11.2km per sec (25,000 m.p.h.) at the start to escape the terrestrial pull and reach the zone of solar gravity. Moreover, the station's starting velocity towards Venus had to be such as to guarantee the entry of the station into the zone of solar gravity at a definite speed also.

Later, on February 18, further news was given. Tass stated:—

The Soviet automatic interplanetary station is continuing its flight to Venus. According to schedule, routine radio contact with the station was established on February 17 at 14hr 04min Moscow time. By that time the station was 1,889,000km (1,173,500 miles) away from the surface of the Earth over a point in the Indian Ocean whose co-ordinates are 0° 39′ South, 54° 37′ East. It was receding from the Earth at a speed of 3.923km per sec (8,750 m.p.h.) . . .

Abundant radio-telemetric information was obtained during the radio link. The elements of the trajectory were measured and the speed determined. The commands transmitted from the Earth were picked up and carried out by the station's instrumented package.

Measurements confirm that the station continues on its way to Venus on a trajectory near to the calculated one. Preliminary figures obtained after the mathematical treatment of measurements showed that the station, after travelling some 270,000,000km (168,000,000 miles) along its orbit from the time of launching, will pass, without trajectorial corrections, at a distance of not more than 180,000km (112,000 miles) from the centre of Venus. At this moment the interplanetary station will be at a distance of some 70,000,000km (43,500,000 miles) from the Earth.

The instrument package of the station functions perfectly. Telemetered data indicate that the temperature inside the station is 28-30°C and pressure 900mm of Mercury. The operation of the solar cells is stable and the charging current of the chemical power source is as planned. The results of measurements carried out by means of scientific instrumentation for space studies are being processed . . .

INTO ORBIT BY SCOUT

First successful satellite launch by the four-stage, all-solid Scout rocket, and the first from the National Aeronautics and Space Administration's Wallops Station at Wallops Island, Virginia, was achieved on February 16. The satellite is a 15lb Echo-type balloon made of mylar plastic and aluminium foil and is 12ft in diameter. NASA officials were at first uncertain whether the satellite had achieved orbit, but were able definitely to locate the balloon on the following day, February 17. The satellite was designated Explorer 9.

The main purpose of the firing was to test the Scout vehicle as a satellite launcher. A secondary objective was to obtain data on the density of the Earth's atmosphere at orbital altitudes. The intended orbit was elliptical, with an apogee of 1,400 miles and perigee of 400 miles. Atmospheric density was to be determined from radio and optical tracking measurements of the changes in the satellite's orbit caused by atmospheric drag acting on the lightweight, yet relatively large, satellite.

This was the fourth flight test of the Scout rocket, which has been under development by NASA for the past 2½ years. On July 1, 1960 a Scout performed satisfactorily on the first of eight development tests. In a similar test on October 4 it performed perfectly. On December 4 the first attempt by Scout to launch a satellite into orbit failed when a defect occurred in the circuit which triggers the signal to ignite the second stage.

In the February 16 firing the rocket payload weighed 80lb. This included, in addition to the 15lb satellite, injection and inflation equipment and a tracking radio in the fourth stage of the Scout. On February 19 it was reported that the satellite and its fourth stage had been photographed in orbit from Woomera. The balloon was then 30 miles ahead of the rocket stage, at an altitude of 1,300 miles.

("Missiles and Spaceflight" is concluded on page 236)

Explorer 9, the 12ft diameter inflatable satellite launched into orbit by Scout from Wallops Island on February 16 (see news item "Into Orbit by Scout"). Temperature reduction is the aim of the reflective-painted circles, which cover 17 per cent of the surface

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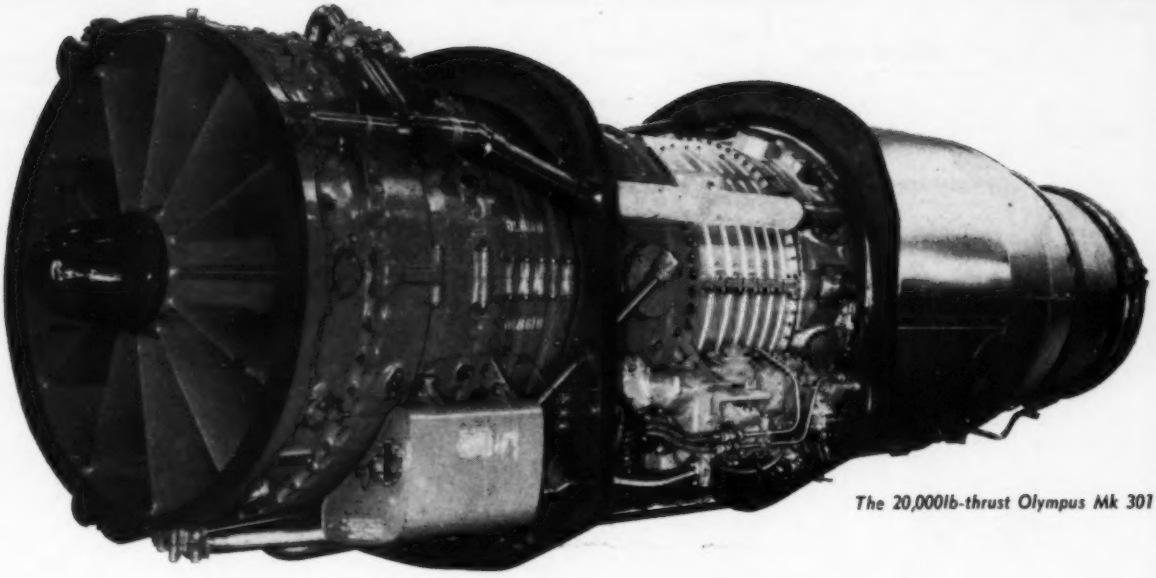


The 20,000lb-thrust Olympus Mk 301

OLYMPIAN HEIGHTS

Mounting Thrust of Bristol Siddeley's Biggest Jet

ONE THOUSAND POUNDS a year sounds good in any language; but to the best of our knowledge Bristol Siddeley's Olympus two-spool turbojet is the only engine in the world to have maintained this rate of growth—the pounds in this case being thrust avoirdupois. In fact, the Olympus has for a decade steadily gained in power at an even greater rate; the BOl.1 of 1950 went on to the bench at a rating of 9,140lb and today's BOl.21 has a dry rating of 20,000lb. Even this is not the whole story, for with reheat the Olympus 21 has recently been giving a corrected thrust of 31,200lb, and still greater power is in prospect.

At the same time, such phenomenal increase in output has not been achieved at the expense of high fuel consumption or short overhaul life. Specific consumption of current production Olympus engines lies between 0.7 and 0.8, and an Olympus on development test recorded 0.68 as long ago as 1958. Overhaul life of 100-series engines is very satisfactory; that of the Mk 101 is one of the highest for any engine in RAF service, and the number of engines removed prematurely is very low. Such results are never achieved by chance.

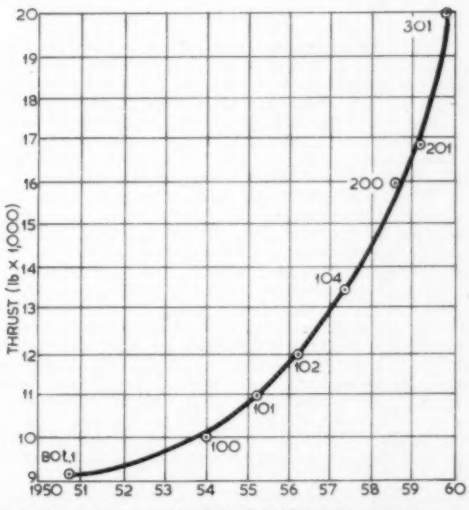
This journal was able to present the first detailed description of early marks of Olympus (issue of December 9, 1955); and in *Flight* for March 7, 1958, we followed up with a lengthy account of the manner in which the Olympus 101, 102 and 104 were standing up to service in the Avro Vulcan B.1s of Bomber Command. It is now possible to comment on the Mks 201 and 301 and describe the Mk 104, the latest version for which internal details may be released. This engine is fitted in the Vulcan B.1, and is at present the most powerful engine in RAF service. Rated at 13,500lb thrust, it is a development of the Mk 101 and 102 engines which were fitted in earlier Vulcans.

Originally known as the BOl.6, the Olympus 200 was the first of a family of redesigned engines in which, as a result of more advanced compressor design with higher work per stage, a pressure ratio of something like 10 : 1 was achieved with only about 12 stages. In many respects the Mk 200 must be regarded as a new engine, and it went into production for the Vulcan B.2 in 1958 at a rating of 16,000lb. Very shortly it was succeeded by the Olympus 201, or BOl.7, rated at 17,000lb, having been type-tested at this figure nearly three years ago. Afterburning versions of this engine have completed a great deal of running at 24,000lb thrust.

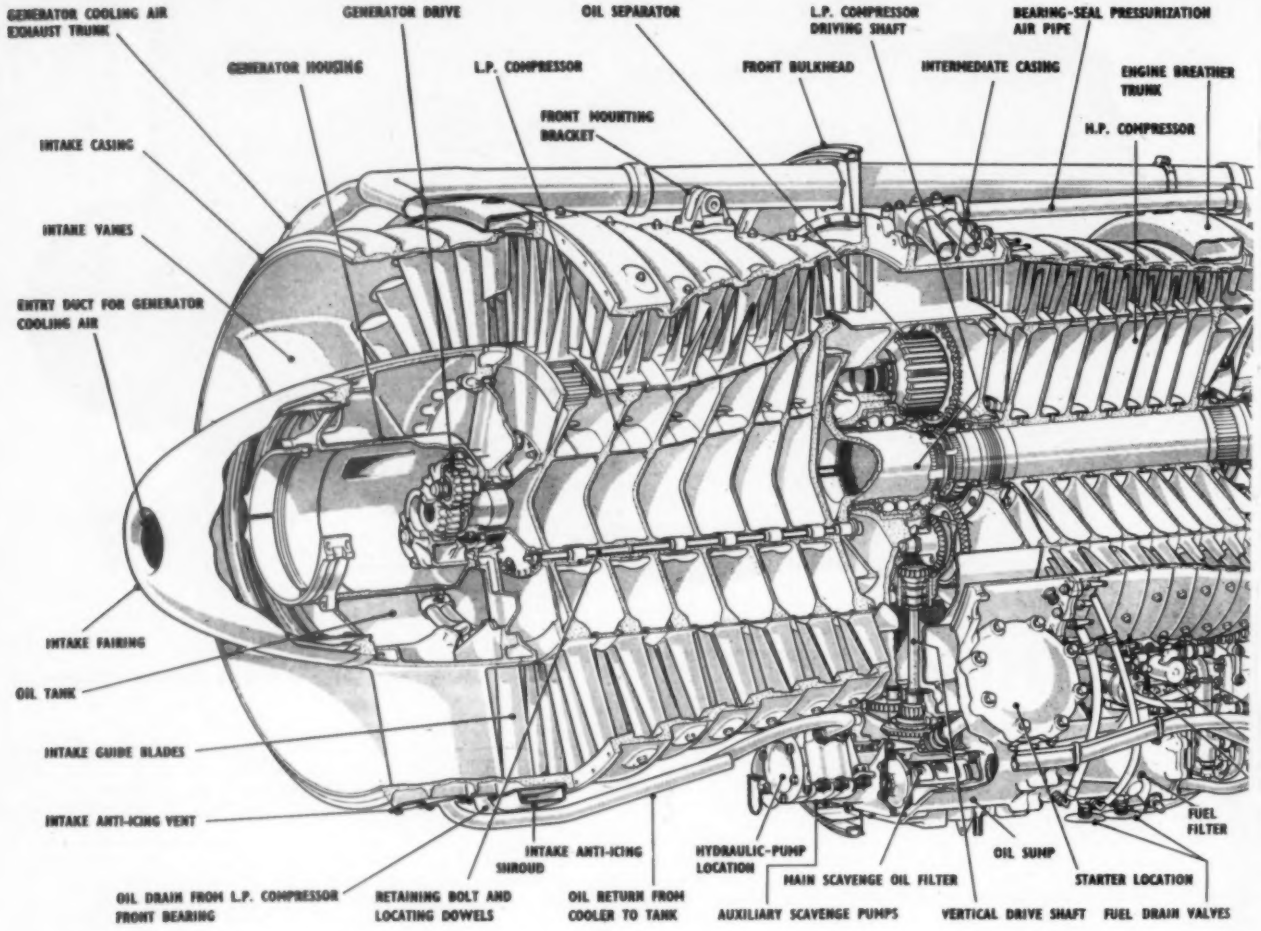
At the time of writing the latest engine of which details are available is the BOl.21, which is now in production at Patchway as the Olympus Mk 301 (heading illustration). Several important differences, notably the addition of a zero-stage on the low-pressure compressor (the second addition of a zero stage, the first having been in the original Mk 102) have combined to raise the dry thrust to 20,000lb. This engine has been described as enabling the full design potential of the Avro Vulcan to be realized, so that a new mark of this fine bomber may be expected. Still later versions of the Olympus, including the BOl.22 and the 22R equipped with an advanced fully variable afterburner, are known to be under development, the obvious application being the British Aircraft Corporation TSR.2. Engines of this type are known to have ratings as high as 33,000lb.

Returning to the Mk 104, it is at once apparent that it has a lower airflow than these very advanced engines, although it retains the "zero stage" introduced in the 102, so that the l-p spool has seven stages. Steel rotor blades and discs are used for the first, second and seventh l-p stages, the remainder being of aluminium alloy. To withstand the higher temperatures employed in the 104—a jetpipe temperature of 660°C is used for take-off—the h-p turbine is bladed with Nimonic 105, and the low-pressure unit with Nimonic 90.

The Olympus was originally designed to give 9,000lb thrust. Despite the increased mass flow, higher component efficiency and



During its first ten years the Bristol Siddeley Olympus has grown in thrust in a manner surpassing that of any other turbojet. This curve, showing ratings of the major variants, does not include the much higher thrusts achieved by reheat engines



This drawing of the Olympus Mk 104 has been prepared by Bristol Siddeley Engines Ltd who manufacture the Olympus at their Aero Division at Patchway, Bristol. The engine differs in many important respects from the earlier unit described in "Flight" for December 9, 1955

Olympian Heights . . .

higher turbine entry temperatures which have been adopted to bring the dry rating up to the present Mk 104 value of 13,500lb, the engine has retained its reputation as a paragon of reliability. For example, last November two 104-powered Vulcans completed a 26,000-mile round-the-world-tour, taking part in the opening ceremony of Rongotai Airport at Wellington, New Zealand. The engine maintenance required was, as at other times, almost negligible, consisting of a visual inspection and filter check after 25 hours' flying (a job which can be done by one man in half an hour). On some global flights the Vulcans have been supported by a Britannia or Hastings (both Bristol Siddeley powered) of Transport Command, but the engine spares carried have invariably been brought back to base intact.

This exceptional reliability—combined with an overhaul life very high by military standards—is largely the result of progressive development of different marks of Olympus before their entry into service. The original BOl.1 made its first run on May 6, 1950. It led to the Mk 101, the first production version, rated at 11,000lb and first run in October 1952. The 101 was fitted with N.90 first-stage and N.80A second-stage turbine blading, and was type-tested in December 1954. Derated to 10,000lb, it flew in a Vulcan in February 1955; it operated at the full rating in July of that year, and entered RAF service with 230 OCU at Waddington, Lincs, in July 1956.

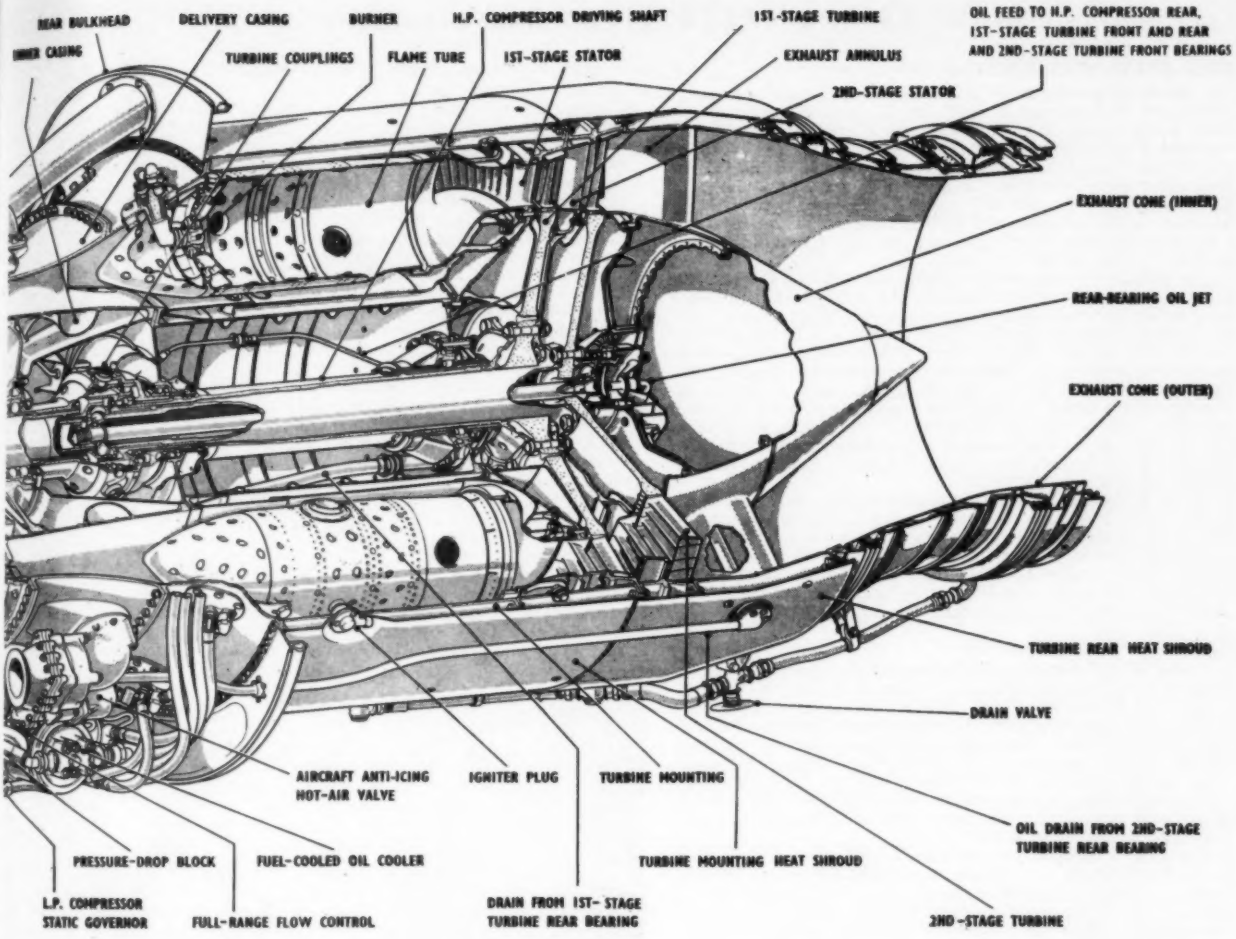
Next to enter production was the 12,000lb-thrust Olympus 102. Compared with the 101, its main difference was the addition of a zero stage to the low-pressure compressor, resulting in increased mass flow. The 102 was improved mechanically, but used the same turbine-blade materials as the 101. It was type-tested in November 1955 and entered RAF service with 83 Sqn at Waddington in July 1957. After overhaul, Mk 102 engines return to the RAF converted to Mk 104 standard, with new turbine discs and blades and burners of increased flow number to allow for the higher fuel flow.

The 104 was initially rated at 13,000lb at 6,500 l-p r.p.m. and a j.p.t. of 645°C, and it was type-tested at this rating in December 1956. The first flight of a 104 took place in Vulcan XA 889 at Woodford in July 1957. In addition to the work with this aircraft, flight testing was carried out by Bristol Siddeley's flight development team, using a Canberra and an Ashton.

One problem was to ensure that the handling of the 104 did not fall short of the standard set by the 102, of which it was stated in an official report that it "sets a standard of handling at altitude which has never been equalled by any other turbine engine. . . ." Initial flight tests of the 104 showed that there was a severe r.p.m. drop at high altitude while climbing. It was found that the air/fuel ratio control (intended to operate only during acceleration, in order to limit the extra fuel flow as a function of compressor delivery pressure), was controlling during steady running and overriding the speed governor. The solution was to introduce a device which automatically isolated the AFRC at altitude. It was also found that the idling speed at 50,000ft was too low, and so the full-range flow control was recalibrated.

Another respect in which the 104 differs from earlier marks is in having "mice," of a total area of 6 sq in, in the final nozzle for trimming purposes. This reduction of nozzle area ensures optimum handling characteristics at altitude. The engine is cleared for operation under icing conditions without any limitation, except for a time limit on the use of low r.p.m. in such circumstances.

The Mk 104 Described Starting at the front, the intake casing is a magnesium-zirconium casting, anti-iced by bleed air. Its hub



houses the front main bearing and d.c. generator, and the inlet guide-vanes are of fixed incidence. The low-pressure compressor rotor is assembled on seven discs, the first two and the last being of Rex 458 steel and the remainder of RR.58 light alloy. They are located by tubular dowels threaded over the eight through-bolts which clamp the spool together. The rotor blades are of the same materials as their corresponding discs, and fir-tree attachments are used throughout. A light-alloy casting, the l-p casing is made in upper and lower halves. Dovetail grooves retain the seven rows of aluminium-alloy stator blades, and the single row of exit blades. The stators are located by stop bolts, against which they are clamped in groups by wedge-bolts.

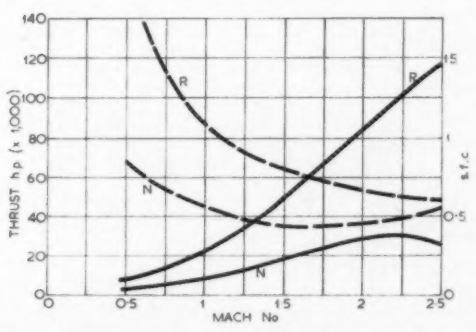
The intermediate casing is in Mg-Zr casting which carries the rear bearing of the l-p and the front bearing of the h-p spools. Mounting faces for auxiliaries are provided on this casing in two groups, one set being driven from the l-p shaft and the other from the h-p. Among the latter group are the fuel and oil pumps, a centrifugal breather within the casing, and the starter. The h-p compressor is similar to the l-p unit, but steel is used throughout. The rotor discs are located relative to each other by Hirth couplings, and axially by means of a nut holding the pack of discs in compression.

The sheet-steel delivery casing carries the h-p compressor rear bearing on its inner wall and the main engine-mounting trunnions on its outer. Ten Lucas A/9 flame-tubes are mounted in the annular combustion chamber. The outer casing comprises front, centre and rear units, the centre portion being split into upper and lower halves to facilitate access to the flame-tubes. The front section carries the forward ends of the flame-tubes and the duplex burners, while the rear encloses the h-p turbine.

All ten flame-tubes discharge into the turbine entry duct, which is supported from the outer casing. Both h-p and l-p stator blades are precision cast in segments of four, the former in Vitallium X40 and the latter in Nimonic 90. They are mounted at their outer ends from the turbine casings, and the l-p stators are dogged at their inner ends to an interstage seal. All rotor blading is shrouded and has fir-tree roots, the h-p material being Nimonic 105 and the l-p being Nimonic 90; discs are of Rex 448 or H46.

In the 104 the turbine casings are stiffened to withstand the higher stresses. Each end of the exhaust annulus is attached by a bolted joint, the downstream end having an articulated section to take up small malalignments between the engine and the jetpipe; the latter is attached by means of a quick-release manacle clamp.

Fuel is fed by a Lucas D-size swashplate pump to the increased-capacity duplex burners, via an air/fuel ratio control, full-range flow control and flow distributor. Since the rotational speed is the same for both the take-off and cruise rating—the extra power being obtained by increasing the turbine entry-temperature—the Olympus 104 requires only a single normally-operative speed governor, though an overspeed governor is also fitted as a stand-by. A j.p.t. limiter can be disconnected by a cockpit switch.



The remarkable performance of the Olympus 301 over a range of Mach numbers at 36,000ft. N and R denote "normal" and "reheat"

MISSILES AND SPACEFLIGHT (continued from page 232)

ESRO MEETS NEXT MONTH

The follow-up meeting to the eleven-nation conference at Geneva (November 28-December 1, 1960) which ended in formal agreement to co-operate in a European space research organization will take place in Paris during March 2-3. The Geneva meeting provided for another conference to be called within one month of the underwriting by member countries of 70 per cent of the total £62,000 required for the first year of the agency's operations. Member nations' contributions are in proportion to their national income, which means that Britain will pay 25 per cent of the total or about £15,000 for the first year.

The purpose of next month's meeting is to elect a Preparatory Commission which will have the task of drawing up a permanent constitution, prepare a detailed programme of space research and work out the finances for this. Each country will be represented on the commission by two members, probably one a scientist and one a civil servant, and these may be assisted by advisers. An executive committee will be formed, together with a number of working groups which will study and report on particular technical questions. The work of the Preparatory Commission is expected to culminate in an inter-governmental conference at which the creation of a European Organization for Space Research will be established by means of a treaty.

One of the urgent problems facing the Commission will be the acquisition of a suitable rocket to put the European instruments into orbit. There is little doubt that, if there is sufficient continental support for the Anglo-French proposals for a three-stage launch vehicle employing Blue Streak as first stage, as discussed recently at Strasbourg (see last week's issue), this vehicle will be chosen in preference to the purchase of American rockets.

RUSSIAN SPACE RESEARCH

Speaking before members of the Diplomatic Corps in Moscow recently, the principal scientific secretary of the Soviet Academy of Sciences, Evgeny Fyodorov, said, "We believe that the exploration of outer space is a matter for all mankind. The Soviet Union does not seek to exploit its superiority in outer space for purposes hostile to other countries." He added that, although biological space research carried out by Russian scientists had established the feasibility of manned spaceflight, "a lot of time is still needed to ensure complete safety for human beings in flight and especially during the return to the Earth."

The speaker outlined the three main trends of space exploration in the Soviet Union: (1) the use of satellites for various types of scientific research; (2) study of the structure of outer space; and (3) study of the Moon and the nearest planets of the solar system. Stressing the difficulty of making direct studies of Mars and Venus, he pointed out that it would be a practical impossibility to set a trajectory with the necessary accuracy from the start of a flight to these planets. In-flight corrections would be needed, and this made it necessary to have reliable communications over distances of over 60 million miles. That problem, he said, would be solved "within the next few years."

Referring to the results of the past three years of Soviet space research, Academician Fyodorov said that previous concepts of the composition and structure of the atmosphere, the structure of the ionosphere and the Earth's magnetic field had been changed substantially. Looking forward, he emphasized that study of the properties of outer space was opening up new possibilities for studying the processes of the formation and development of the stars and for studying the nature of gravitation and the nature of time.

MOSCOW MEETING

A conference of satellite-tracking observers from communist countries was held recently in Moscow, at which reports on visual and photographic observations of satellites were discussed. The staffs of the astronomical stations involved, it was reported, had conducted approximately 22,000 observations of artificial satellites, and new and improved equipment for this work was described.

Mrs Alla Masevich, vice-chairman of the Astronomical Council of the Soviet Academy of Sciences, congratulated the staffs of the monitoring stations in Bulgaria and Hungary, and asked Dr Hsiao Kwan-chia to convey thanks to observers at 24 Chinese stations which had made a great contribution to the study of Soviet artificial satellites. The conference was said to have taken decisions "aimed at further developing and co-ordinating the monitoring of sputniks."

CONTRACT FOR NIMBUS

The Missile and Space Vehicle Department of the General Electric Co, Philadelphia, has been selected by the US National Aeronautics and Space Administration to negotiate for construction of the first two Nimbus meteorological satellites and for the integration of subsystems for the spacecraft. The contract, which will be worth some $4.5m, follows proposals made by six companies to NASA's Goddard Space Flight Center.

Nimbus will differ from NASA's first meteorological satellite, Tiros, in two respects. First, it will be oriented so that the television cameras will look down at the Earth at all times. Secondly, it will be launched into a polar orbit, permitting the photography of the whole globe in each 24-hour period.

The first Nimbus will be launched by a Thor-Agena B vehicle from the Pacific Missile Range into a 600-mile circular orbit. This should take place during 1962. The spacecraft will weigh some 650lb and will carry up to six television cameras, which will be improved versions of those carried in the Tiros series. Infra-red radiation measurements will also be made. Two large solar-cell paddles will be used to provide electrical power to operate instruments and to charge batteries.

Cloud-cover pictures and other data stored in the satellite will be played back by command from the primary data-acquisition site at Fairbanks, Alaska. Scientists in other countries will be invited to participate in the meteorological aspects of the Nimbus programme. Contractors for the various subsystems are RCA Astro-Electronics Division (cameras and solar power system), International Telephone and Telegraph Laboratories (infra-red equipment), Santa Barbara Research Center (infra-red equipment), Radiation Inc (telemetry system) and California Computer (command system). General Electric will be responsible for the control and stabilization system.

NEW NASA CHIEF

Mr James E. Webb, a former Under-Secretary of State and Director of the Bureau of the Budget, has been chosen by President Kennedy to be the new Administrator of the National Aeronautics and Space Administration. Mr Webb is president of Educational

Mr Webb

Dr Glennan

Services, a non-profit firm engaged in teaching physics in high schools; a director of McDonnell Aircraft Corporation; and a director of Kerr-McGee Oil Industries.

The retiring Administrator, Dr T. Keith Glennan, is returning to his presidency of the Case Institute of Technology in Cleveland.

THIS YEAR'S SPACE CONGRESS

Washington DC—not New York as previously announced—is to be the location of the 1961 Congress of the International Astronautical Federation. Organized by the American Rocket Society, the meeting will be held during the week of October 2-7. This will be followed during October 9-13 in New York by another major spaceflight function, an exhibition (also organized by the ARS) entitled ARS Spaceflight Report to the Nation.

The Saturn booster is being seriously considered in place of the Titan 2 as the launching vehicle for the Dyna-Soar spacecraft.

The West German Rocket Society fired two rockets destined to form the second stage of meteorological research sounding rockets to a height of 55,000ft on February 12. Weighing about 42lb each, the rockets carried neither scientific instrumentation nor guidance.

Voice messages transmitted from the United States and reflected from the surface of the Moon were received at the Woomera Range, Australia, on February 11. The messages included one from Dr Hugh Dryden, Deputy Administrator of NASA, to Mr Alan Hulme, Australian Minister for Supply, and one from Dr W. A. Pickering, director of the Jet Propulsion Laboratory. Dr Dryden's message was relayed from Washington by ground line to the Goldstone Tracking Station in California, from where it was transmitted by radio, via the Moon, to NASA's Island Lagoon tracking station, 16 miles north of Woomera village.

Mr Davies
(Manager, Agricombine Air Division)
buys a cropsprayer

'Aerial top dressing' (that's the correct phrase) can save a farmer thousands of pounds. Trouble is, the capital cost of the equipment is prohibitive—out of the question for most individual farmers.

Mr Davies' company was started to solve just that kind of difficulty. It makes available earthmoving plant, pumps, trenchers and so on to farmers who have no all-the-year-round need for such things. This cropsprayer is just the latest item in Agricombine's comprehensive range of equipment, held ready for when the occasion arises.

Like all their equipment, Agricombine's cropsprayer is being bought through UDT. They reckon that most of their equipment pays for itself—and more—over the months. So the purchase of this plane becomes a simple entry in the company accounts, paid for over a period with no strain on capital.

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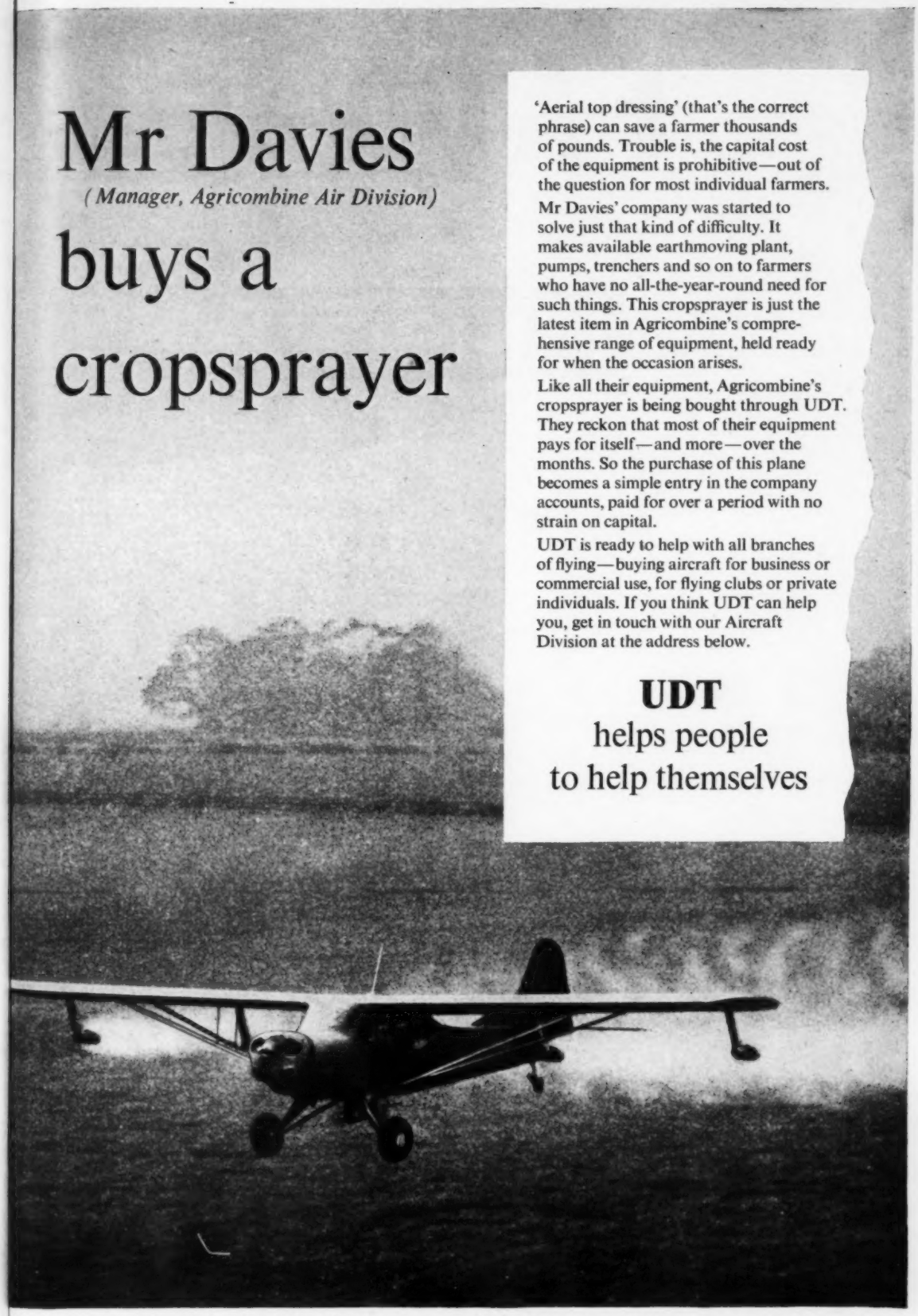

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FLIGHT SYSTEM SURVEY

This "Flight" special feature gives a detailed review of the problems of helicopter all-weather operation. The general discussion below is followed by reports of relevant work by Louis Newmark Ltd (page 243), Sperry Gyroscope Company (page 244) Ferranti Ltd (page 246) and of developments in the United States (page 247). A review of data link in air traffic control begins on page 251; a report on flight recorders is on page 254.

A Westland Widgeon at Battersea Heliport (lighting by G.E.C.)

Helicopters, all-weather

MULTI-ENGINED commercial helicopters have now reached the state of development where delivery to airline operators is about to begin. This fact immediately opens up the prospect of all-weather or poor-weather operation on a basis of equality with fixed-wing airliners, whereas existing passenger helicopters have been limited both in routes and in weather minima by virtue of their single-engined powerplants. Twin engines form the basis of safety on which all-weather capability can be built up, using the knowledge of flight controls, instruments and radio aids accumulated in fixed-wing experience.

Nevertheless, the problem of providing a helicopter with the equipment necessary for something approaching all-weather operation differs in several important respects from that of fixed-wing aircraft. Automatic control and instrumentation will be introduced in stages and at first it will not do much more than make the transport helicopter capable of flying in cloud *en route* without necessarily reducing the present special VFR minima for take-off and landing. There is still no commercial helicopter instrument rating on which to base pilot qualification.

A great deal more than this is already being achieved in military helicopters, some of which can now hunt and attack submarines under almost completely automatic control. The Westland Wessex and its US Navy counterpart, the Sikorsky HSS-1N, have the Lear 1N system incorporating Doppler, radio altimeter and sonar cable-angle and extension detector to control the entire submarine search operation from take-off to hover over the landing pad. Even more advanced systems are under development for the same general purpose, but none of them is suitable for civil transport helicopters, either from the point of view of safety by duplication or in the type of flights for which they are intended. More particularly, the weight of these comprehensive systems is considerable and occupies much of what should be payload in a civil machine. But the knowledge and techniques are undoubtedly available and it is the specific application to civil operation in an economical form which is the main object of this study.

Certain basic flight-characteristics make the helicopter either difficult and tiring or impossible to fly by reference to the six conventional flight instruments alone. At moderate forward speeds and in reasonably calm air a helicopter equipped with gyro and pressure instruments can be flown blind; and GCA approaches in forward flight down to about 100ft or 50ft are a standard military training exercise. Transition to the hover is made visually. But in turbulence, instrument flying is excessively tiring and it is quite possible for even a very experienced pilot to become disorientated and lose control. There is certainly no prospect of operating passenger-carrying services with this scale of equipment.

In forward flight, a helicopter is unstable. With stick fixed, a Whirlwind flying at 40kt will diverge from trimmed attitude in an oscillation which doubles its amplitude in half a cycle, or about 15sec. The Sycamore is rather better; and the Bell and Hiller types, whose stabilizer bars impart some gyroscopic stability to the rotor head, are substantially neutrally stable. Characteristics can vary considerably between individual machines of the same type. Aerodynamic surfaces at the tail can provide reasonable stability in cruising flight, but they lose their effectiveness at low airspeeds.

The problems become more acute at lower speeds. As the

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FLIGHT SYSTEM SURVEY...

helicopter slows down in level flight engine power can be progressively reduced, but a point is reached where power must be increased if height is not to be lost. From just above this minimum-power speed downwards, flight by sole reference to conventional instruments is regarded as virtually impossible. The fuselage attitude no longer represents the direction of movement of the helicopter and pressure-sensing instruments cease to operate. While accurate transition from forward flight to the hover with conventional instruments is considered virtually impossible, acceleration into forward flight is practicable as a "panic" manoeuvre. Full power and some nose-down attitude will provide simultaneous climb and acceleration to a safe speed in a sufficiently short time for full forward flight to be achieved before control is irrevocably lost.

At the hover, a fuselage displacement in any direction immediately results in horizontal motion in that direction. The minimum-power speed in a Whirlwind is about 40kt. Minimum-power speed increases with the size of the helicopter and aggravates the problem, especially in relation to instrument approaches.

A further complication is the helicopter's additional control, the collective-pitch lever. Although this may be locked and virtually ignored for most of the time in cruising flight, it assumes primary importance in height control below the minimum-power speed. Directly connected with collective pitch-control in some helicopters is engine-power control. These two controls often need constant, co-ordinated manipulation, and this in itself requires considerable concentration.

In the early 1950s the conclusion was reached both in Britain and the US that stability augmentation or autostabilizers must be the true solution to the helicopter flying problem. Almost every helicopter manufacturer has come to realize that artificial stabilization, based on rate or attitude gyros, is an acceptable, and the most effective, way of giving the helicopter a stability comparable with that of the fixed-wing aircraft. Though aerodynamic surfaces can perform a similar function they are relatively heavy and cease to be effective at low forward speed, when they are often most needed. A "black box" can be lighter and smaller and acceptably reliable, especially if it is designed as an integral part of the control system. In 1954, RAE Farnborough was working on autostabilizer development and the US Navy briefly introduced into service the Bell HSL equipped with roll and pitch dampers.

Almost every large helicopter now has fully powered controls and many—notably the Sikorsky range—have no manual reversion. Twin jacks are supplied by individual hydraulic pumps, one driven by the transmission and the other by the engine. The reliability record of these systems is extremely good and the low effort required to operate the valves greatly simplifies the addition of autostabilizer or autopilot servos. Just as complete reliance is placed on powered control, the tendency is to provide duplicated autostabilization so that, in theory, the helicopter need never be flown in its natural unstable condition.

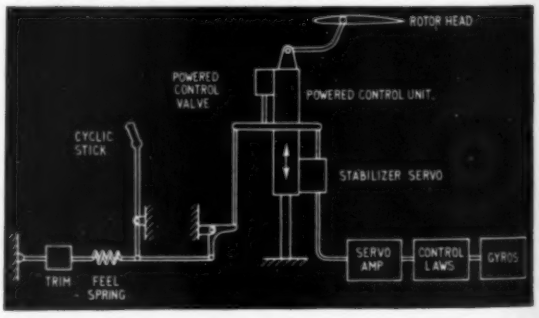
The addition of autostabilization radically changes the control picture. The helicopter sheds its inclination to depart from trimmed attitude, even with the stick free; and, according to the actual system parameters, it has a greater or lesser tendency to return to trimmed attitude if it is disturbed by external forces.

Either attitude gyros or a group of rate gyros may be used as the signal source for an autostabilizer, the displacement signals being shaped in conventional circuitry, amplified and used to operate servos in the roll and pitch control linkage. The stabilizer is arranged to respond quickly but over only a limited portion of the available control travel. The servos are placed in series with the pilot's controls, so that servo outputs are not reflected by cyclic-stick movements. Because the pilot's control demands would tend to be cancelled by compensating autostabilizer demands, some form of feed-back is applied to inhibit the autostabilizer when the pilot is trying to manoeuvre. The small available movement of the servo is intended to limit its power; and it is additionally arranged to react into the feel spring at the base of the cyclic stick. Hard-over run-away autostabilizer demands cannot, therefore, produce drastic results. Feed-back from the cyclic stick may be provided by means of force- or position-pick-offs, or by micro-switches on loose links in the control runs. Trim settings may be altered by conventional positioning of the feel spring or by applying precessing currents to the rate gyros. Fig 1 illustrates a simple series-servo autostabilizer channel.

The autostabilizer for the Vertol 107 is an integral part of the control system and is fully duplicated. Called SAS—stability augmentation system—it includes three hydraulic jacks, weighing 5lb each, and independent, duplicated electronic circuitry without any thermionic tubes. Total weight, with wiring, is 23lb. SAS operates over the full speed-range and will, it is claimed,

Cockpit of a Westland Widgeon, showing conventional blind-flying instruments. Without autostabilization, instrument flying for any length of time would be very tiring

Fig 1. Schematic layout of an autostabilizer system. The stabilizer inputs are in series with the pilot's control runs, and its servo loads are reacted against the feel spring



Two Westland Wessex anti-submarine helicopters, equipped with the 1N system, made under licence by Louis Newmark Ltd, flying out over the south coast

"Flight" photograph

A Sikorsky HSS-2 of the US Navy hovering while dipping its sonar ball. Position and height are controlled by sonar cable-angle and ball depth

hold an attitude for up to five minutes. At speeds above 40kt it will produce properly co-ordinated turns. In 1950 Vertol produced for the little HUP a stabilizer with a heading lock. Because stabilizer demands moved the cyclic stick, the pilot was provided with a small hand-grip for flying in the stabilized mode—a system which was not greatly liked at the time.

Autostabilization in pitch, roll and yaw axes makes prolonged cruising flight by sole reference to conventional instruments quite feasible. But the problems of control below minimum-power speed remain and there is still no assistance in vertical (collective-pitch) control. Near the hover, conventional pressure instruments become ineffective and the gyro instruments indicate only attitude and can give little or no indication of horizonal motion relative to the ground which follows every attitude change.

The very important, but limited improvement afforded by autostabilization proved insufficient for the military requirements of anti-submarine warfare. Helicopters with dunking sonar equipment have to take off in groups in virtually any weather and move to pre-determined positions relative to a moving ship to form a screen around it. Each helicopter must dip and listen at intervals and move on a predetermined distance on the ship's heading in order to maintain the screen. If a contact is made, one or more helicopters work to pin-point the target. Then an armed machine must be guided to the spot to release a homing torpedo or depth-charge to make the kill.

To perform such a mission on a pitch-dark night in high winds obviously requires a far greater degree of automation than is implied in autostabilization alone. First requirement is the ability to come to a hover at a predetermined height—about 30ft—and remain stationary relative to the water surface. The transition from and to the hover must also be automatic. Full automatic stabilization, including collective pitch, engine speed or power and heading, is necessary; and the system must be referenced to the water surface and not merely to attitude or height. Doppler radar and the radio altimeter effectively provide the references. Finally, hovering position during sonar dipping is controlled by sensing cable-angle and sonar-ball depth.

The Lear 1N System, now being produced in Britain by Louis Newmark Ltd as the Mk 19 autopilot, comprises electro-mechanical autostabilization equipment using differential electrical signals to control attitude, height and power by means of electric servos directly operating the powered-control valves. Gyros and accelerometers provide pitch, roll and yaw attitude, acceleration, and rate-of-turn signals. Either barometric or radio-derived height, and stick position, automatic trim and engine power-output, are sensed. Navigation and hovering data are derived in the form of Doppler heading velocity, drift velocity, vertical velocity and sonar cable angle and ball depth. A coupler computes the appropriate control movements to bring the helicopter from a cruising height and heading to a hover close to the water. After taking off, the pilot presses the appropriate rudder pedal to attain a pre-computed heading to his screen position. He adjusts this by reference to Doppler drift signals to make good the required track.

The Doppler used is the Ryan APN-97A, a CW, four-beam system transmitting on 13,300Mc/s. It can measure heading speeds, drift speeds and ground-speeds of ±150kt, any drift angle, and vertical speeds of ±2,000ft/min. Equipment weight is 35.2lb, and the two fixed aerials and transmitter/receiver are contained in a single unit. A convertor/power-supply derives drift, speed and vertical speed signals, which are fed to the autopilot and to a cross-pointer instrument for monitoring. When the pointers are zeroed the helicopter is stationary; any displacement of the cross-over point of the needles indicates a control demand—not an attitude demand—to regain a "solid" hover. Beside the cross pointers is a marker which shows collective-pitch control required to maintain preselected height. The instrument receives DC analogue currents and the autopilot AC analogue voltages.

In the hovering mode, velocity in any direction is sensed almost immediately by the Doppler and the controls are moved to return groundspeed to zero. Reference voltages corresponding to desired heading and drift are manually set to produce the desired course in cruising flight.

Ryan have also produced a more advanced Doppler, the APN-130, which can detect vertical velocities up to ± 3,500ft/min. It feeds the autopilot and the Loral Electronics ASA-13A navigation computer and dead-reckoning position indicator. Additional inputs are gyro-magnetic heading, computed true airspeed and wind speed and direction. A pre-determined navigation pattern can be marked on the circular face of the dead-reckoning position indicator and the actual course of the helicopter is shown either by a lighted silhouette projected from beneath the translucent surface of the plotter or by a tracing pen. N-S and E-W distances (either Doppler- or DR-derived), true heading and wind speed and direction are separately displayed. This more advanced system gives better navigational capability. Other navigation computers may be used in conjunction with Ryan APN-130 Doppler. Navigation computations of the ASA-13A are made on a flat-Earth basis, because of the short distances involved. Where ships or shore form navigational hazards, search radar either in ships or in the helicopters may be used.

There is a requirement for a relative-navigation device by which one helicopter can direct other machines to the exact location of a contact. Here the problem is to provide a common reference system over a radius of only a few miles where the only geographical reference is the position of the "master" helicopter. It may be wasteful or tactically impossible to employ search radar or any extensive radiation for position-fixing. Telemetering of Doppler-derived dead-reckoning might provide a solution.

The above details of the 1N and derived systems, necessarily limited by security restrictions, indicate the degree of automation which has to be accepted for anti-submarine operations. Without equipment on this scale the virtually all-weather requirements, dictated by an equivalent capability on the part of the submarine, could not be met. But during operations with the 1N system the pilot is so completely committed to automatics that he has relatively little hope of recovering manually if a run-away failure should occur in instrument weather or at night. The instrument indications which he has before him on the panel show the basic parameters with which the autopilot is operating. It has already been pointed out that conventional indicators, or even directors, do not allow even a stabilized helicopter to be effectively flown blind at the hover. It has not been stated how well the pilot could hover by reference to the cross-pointer hovering instrument; but a major system failure is in any case likely to affect this instrument. The best hope of escape from a failure is the "panic" full-power transition to something above minimum-power speed mentioned earlier. A hovering height of 30ft certainly leaves little margin for hesitation or error.

Even though the basic control problem has been solved, much remains to be done before the techniques can be applied to civil operations. Fundamentally the task is to develop the capability first to control the helicopter effectively at all speeds from maximum cruising down through the minimum-power speed—though not necessarily right down to the hover—and to develop at the same time the ability to navigate blind and follow ATC instructions.

The single-engined helicopters now used for passenger services, notably by Sabena in Europe and by New York Airways, Chicago Helicopters and Los Angeles Airways, are at present limited to operation in special VFR conditions. Their routes are also restricted to avoid overflying built-up areas—mostly to follow water courses which will provide a forced-landing area in towns. BEA special VFR minima are 500ft ceiling and half-mile visibility. Sabena's minima are 300ft ceiling and half-mile visibility, the low ceiling being possible because of generally low-lying land in their area of operations. Over New York, NYA have ceiling minima as high as 1,500ft on some routes, because of much greater obstacle heights and the need to reach water in case of engine failure. Forced landings on land are not contemplated, and the necessary flotation gear is a payload penalty.

Obviously, poor-weather operation will be achieved in easy stages, the first probably being *en route* IFR capability, retaining existing take-off and landing minima. NYA Vertol 107s, to be

Suitable forced-landing facilities for single-engined helicopters are usually provided by water. A Sikorsky S-62 here shows its marine capabilities on the Thames near Battersea Heliport

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SYSTEM SURVEY...

delivered in less than two months' time, will have duplicated autostabilizers and conventional gyro instruments. The object is to be able to operate in the existing relatively high ceilings, but in reduced slant visibility. The pilot would continue to control attitude largely by visual reference to the ground, but would navigate by means of radio aids, notably duplicated Decca Navigator.

It seems to be generally agreed that the helicopter working on short routes into city centres cannot afford for economic reasons to become directly involved in fixed-wing traffic patterns. This pre-supposes the use of discrete routes, which will probably not be effectively marked by existing radio beacons. The normal VHF navaids are in any case unlikely to provide adequate coverage at low altitudes over built-up areas. An area-coverage aid strongly suggests itself—unless Doppler used on short sectors, or MF beacons, can provide acceptable accuracy. The ability of Doppler to operate accurately at low level over built-up areas is not yet proved.

There is also a likelihood that the large helicopters will carry a "conventional" aid, such as ILS, to enable them to use fixed-wing airports as a diversion. There seems to be no acceptable alternative to VHF radio as a communications medium. Over southern and central England VHF coverage at low altitude is very good, but in the New York area, for instance, several repeater stations have been set up to ensure coverage at the heights at which the helicopters in the experimental all-weather programme fly.

The equipment mentioned above is conventional, and the considerations governing its installation are those of weight and safety. Yet, with such adjuncts as cabin-address and intercom, it could account for an addition of something like 1,000lb in weight and the choice would therefore have to be shrewdly balanced with economy.

It is likely that the large helicopters will operate over sector distances of up to 200 miles, involving about one-and-a-half hours' flying. With an additional allowance of up to 1hr for diversion or other contingencies, a total flight-time or trip length of some 2hr to 2½hr would have to be reckoned. For this length of time it would be necessary to provide the pilot with some form of assistance beyond plain autostabilization. There are two alternatives—either a flight director instrumentation specially designed for helicopters, or an autopilot. Both can achieve the same result, the director retaining the pilot as the servo system, while the autopilot leaves the human pilot free to perform other tasks. The more the autopilot is designed to do, the more necessary does a monitoring device become. With autopilots designed to make automatic approaches down to speeds below the minimum-power level, an independent director instrument for monitoring purposes will almost certainly be a firm requirement.

The "mission profile" diagrams (Figs 2 to 5) show the probable stages of helicopter IFR development, from the present special VFR limits to the ultimate virtually blind-flying stage. Special VFR (Fig 2) implies limited use of navaids, because map-reading is fairly easy, especially at present cruising speeds of about 80kt. In a 500ft ceiling and half-mile visibility, attitude control is always possible by visual reference to the ground and none of the present helicopters carries even autostabilization. Severe limitations apply, particularly in adjusting routes to obtain obstacle clearance and, in single-engined helicopters, following routes which provide continuous forced-landing facilities in the form of water or open ground.

Autostabilization and better conventional flight instruments will allow operations in rather poorer visibility, but there will be virtually no improvement in take-off and landing conditions, except by the use of an area-coverage navaid allowing slowing-down and initial preparations for landing to be completed while the heliport is still out of sight.

The first extension—the ability to cruise in or above cloud, but with the same minima for landing or take-off—is illustrated in Fig 3. It implies the ability to fly the aircraft for prolonged periods on instruments and to navigate without sight of the ground. "VFR on top" is then possible. Autostabilization and at least an efficient director system for cruising speeds become a necessity. As soon as the helicopter operates in or above cloud, twin-engined safety is also a must, because allowance for forced-landing cannot be effectively made once the ground is out of sight.

The advantage of *en route* IFR capability is a much greater freedom in choosing routes and the ability, for example, to fly airways during all or part of inter-city flights. High ground or tall buildings no longer provide *en route* hazards, although they must still be allowed for in the climb and descent phases. An additional requirement is, however, effective icing protection; and the weight of this must count as a penalty of *en route* IFR capability.

One complication of flying fixed-wing airways on the longer inter-city routes will occur in joining and leaving airways. The helicopter could leave airways at the edge of the terminal control zone for a city and make its way on special VFR lanes at low altitudes, but this might prove lengthy and difficult in places such as London, where the main approach lanes to the heliport area on the Thames lie close to the most frequently used ILS approach to London Heathrow.

A Chicago Helicopter Airways S-58 flying over typical American city-centre scenery. Transport helicopters must be able to operate beside, rather than over, such terrain

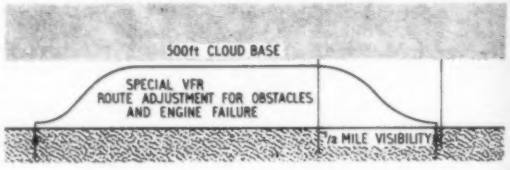


Fig 2. Flight profile of present special VFR type of operations

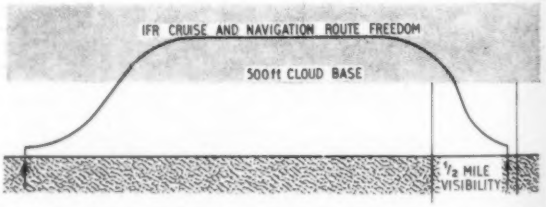


Fig 3. Flight profile for the first stage of IFR operation, involving en route IFR flight

Fig 4 illustrates the probable configuration of an IFR approach in ceiling and visibility corresponding approximately to existing fixed-wing minima—ceiling between 100ft and 200ft and visibility of about ½ mile. The end of the navigation or *en route* leg would be followed by a descent, in cloud at normal cruising speed, to an initial approach height. The helicopter would then have to slow down to its final approach speed of about 30kt and lock-on to the final-approach aid, descending on a 15° glide-slope, still in cloud. In the worst conditions, the time and the visual range available on emerging from the cloud-base would probably not be sufficient to guarantee a successful transition to hover by visual reference alone, and some automatic slowing-down and levelling-off mode would be required in the director or autopilot system. Visual contact with high-intensity lighting would certainly be established during the final slowing-down stage and the final hover and landing could be made visually. The lowest speed attained during the automatic slowing-down manœuvre would be governed by the minimum level engine-out speed of the helicopter (in the case of the Rotodyne this speed is about 26kt). In the lowest visibility conditions some automatic means of overshooting would be necessary.

In this type of operation take-off minima would depend on the rapidity with which the helicopter could safely make the transition

into its slowest automatically-controlled speed and on its ability to continue the climb or find its way back to the landing site in case of engine failure. The solution depends in this case largely upon the performance of the helicopter. Take-offs in rearward flight to allow an immediate normal landing in case of engine failure look less attractive in the case of a low ceiling, because the pilot would have to make a complete transition from rearward flight to the hover, and then into forward flight, entirely on instruments or autopilot. It is conceivable that the rearward climb-out might be made up the glide-slope of the precision aid, the transition being made by coming part of the way down the glide-slope again and then virtually taking overshoot action into a normal forward climb-out. It would seem more practical to ensure the ability to make the standard climb to obstacle clearance height regardless of engine failure and then to be able to make a circuit and standard approach with an engine out. Such problems obviously become less severe with three or four-engined helicopters.

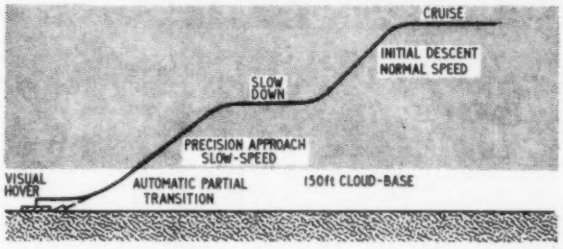
Fig 5 illustrates the possible configuration of an approach in ceiling-zero conditions, the actual visibility minima being dictated by the ability of the heliport to operate efficiently. The approach path from cruising height would be the same as before, except that the helicopter—and it would almost inevitably be a three- or four-engined type, able to hover outside the ground-cushion with an engine out—would make the transition to a blind hover at 100ft or 200ft. The final descent would be made vertically over a radio beacon and the pilot would probably first have accurate visual contact with the ground just before touching down. The high-intensity light pattern would be largely obscured from view beneath the helicopter airframe until the last moment.

There is a strong case for relying on high-intensity lighting and visual contact for the final landing in order to avoid highly complex and probably uneconomical equipment. The final distance to be covered and the duration of visual flight would be very short; and high-intensity lighting can probably penetrate light fog conditions below which it would rarely be necessary to operate. The improvement in regularity achieved by automating the final 100yd and 30ft or so of the approach would hardly warrant the considerable performance margin and special equipment involved.

BEA Planning British European Airways' Helicopter Experimental Unit, based at Gatwick, has since 1947 been engaged in research into the requirements of helicopters in scheduled passenger operation and has completed considerable investigations of the equipment available and the control techniques which would be required. Members of the unit have probably done more practical work on IFR operations than anyone else and have actually made equipment proposals for specific aircraft. Their conclusions indicate that new and specialized equipment is required in almost every phase of IFR helicopter operations, except possibly for communications. During the night mail flights in East Anglia in 1949 they were the first to fit gyro instruments and fly at night without visual reference.

In the very early days they realized the need for autostabilization as a basic part of the control system. They now consider that an electro-mechanical system intended only for stabilization, and not for flight-path control as well, can be integrally designed with the primary controls; and that, if it is duplicated, it can be fitted

A typical European city-centre heliport, the Sabena terminal in the Allée Verte, Brussels. The farther S-58 carries flotation gear, not inflated, on its wheels



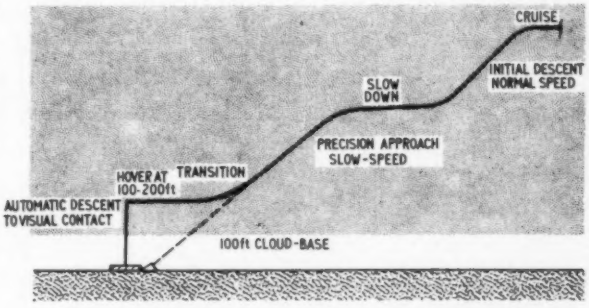
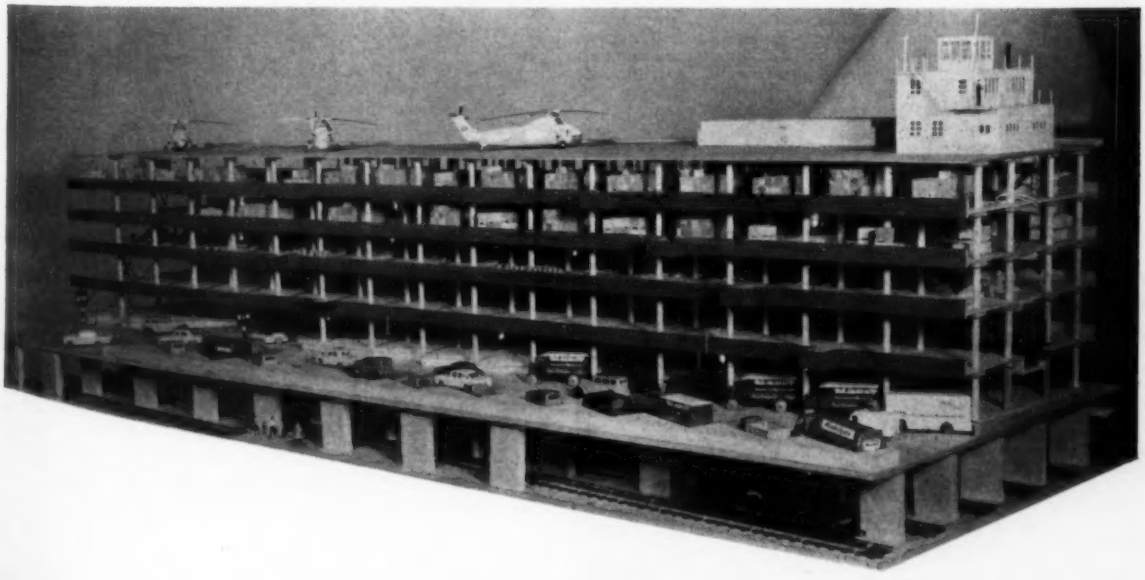


Fig 4 (upper drawing) and Fig 5 show respectively the flight profiles for IFR operation with visual hover and touch-down, and extreme IFR operation with blind transition, hover and vertical descent to visual contact with the heliport lighting

Model of one-tenth of the proposed replacement for Covent Garden Market, which would be built over King's Cross, London, railway sidings and surmounted by an 800ft×1,200ft heliport. (Architects, C. W. Glover & Partners)



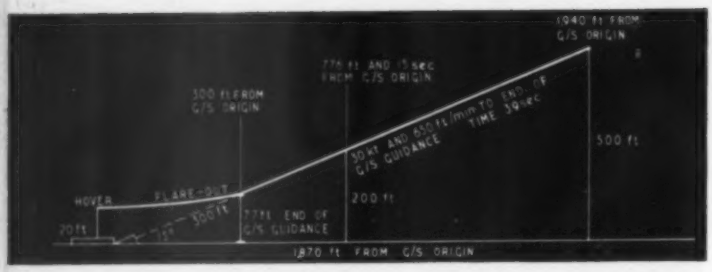

1940 ft FROM G/S ORIGIN
776 ft AND 15 sec FROM G/S ORIGIN
300 ft FROM G/S ORIGIN
30 KT AND 650 ft/min TO END OF G/S GUIDANCE
TIME 39sec
500 ft
HOVER
FLARE-OUT
200 ft
776 ft END OF G/S GUIDANCE
1870 ft FROM G/S ORIGIN

Fig 6. Approach configuration from 500ft to the hover, using a precision approach aid down to a range of 300ft. According to the size of helicopter, the flare-out and transition would have to be started at between 77ft and 200ft above heliport level

FLIGHT SYSTEM SURVEY...

for an additional weight of as little as 50lb. A stabilization system not designed as an integral unit would weigh between 80 and 100lb.

In a Whirlwind, BEA evaluated the Newmark Mk 14 autopilot and carried out extensive flying with Decca Navigator both as an approach and *en route* aid. Employing Decca with large-scale Flight Log charts, they made the first completely blind helicopter landings in a Sycamore as long ago as 1954. A lighting pattern, based on the Calvert principle, was developed and demonstrated during 1958 and is now used in conjunction with visual glide-path indicators. Both VHF and visually simulated approach beams have been tried at various glide-slope angles; and an Elliott microwave harbour beacon, which gave good performance close to obstacles, was also evaluated. The Bendix sonic altimeter was tested and considerable work was done in conjunction with Sperry on the adaptation of the Zero Reader as a flight director. This particular line of development has resulted in a Sperry venture, further details of which are given in another section of this review. Early experiments involved the use of a Zero Reader computer modified to accept additional signals from three rate-gyros and cyclic stick-position. An i.a.s. term was then added to assist in speed control. As an interim measure the Zero Reader was positioned next to a conventional artificial horizon to provide the attitude background; and an early Smiths Para-Visual Director was fitted to give vertical guidance.

BEA estimated that an autopilot in which long-term signals for cruise control were fed into the stabilizer servos might add 75lb to the weight of the helicopter. Of this, some 20lb might represent a rotor speed control, if this was not already provided.

Operational research was directed initially to a specification for navigation and flight-control equipment for the Rotodyne. BEA decided that for the type of operations the Rotodyne would be required to perform they would need duplicated autostabilization and duplicated rotor speed-control as basic items. To this would be added a four-channel autopilot (pitch, roll, yaw and collective-pitch) with modes for attitude holding, course holding, radio aid-coupling, height or speed lock, automatic slowing-down to minimum level single-engined speed, and coupling to an approach aid. A flight director with the same modes would be provided as a stand-by to the autopilot to allow monitoring and manual take-over as a final resort. Autopilot and director instruments would have common switching, but there would be a separate control computer for the instruments.

There is a problem in obtaining accurate air data at low speeds, because of interference of rotor downwash with the pressure head. Height, airspeed and rate of change of height signals are needed; and an air-data computer to relate indicated dynamic and static pressure to engine power-output might provide acceptable information at airspeeds down to 20kt. The air-data computer would also have to be duplicated. Total weight penalty of the whole flight control system might be 500lb.

En route navigation aids would, as stated before, probably include one unit of the standard airways aid as a back-up, but would probably be based on Decca Navigator. There is a prospect of a duplicated Decca combination in which the primary receiver would operate a Flight Log and the secondary receiver would be simplified and intended to operate a "ghost buoy" course computer serving a left/right needle and autopilot coupler. The two sets together might weigh 100lb. Conventional ILS and marker beacon might be included as a stand-by in case the helicopter had to divert to an airfield. A cabin-address system is required.

The approach problem calls for a relatively steep glide-slope in order to reduce the terminal area around a heliport. The helicopter would descend at 15° and at about 700ft/min at an airspeed of 30kt, i.e., below minimum-power speed. Director or autopilot in roll and pitch axes and for collective-pitch would be necessary, with yaw control for the final hover and landing. Limited freedom in choosing approach directions would probably make cross-wind approaches necessary and drift angles of up to 40° could well result, because of the very low airspeed. The ideal rate of descent would be 700ft/min, with a maximum of 1,000ft/min when regaining the glide-slope after deviating. Minimum cloud-base would probably be about 150ft; below this, engine-out performance would mainly dictate the approach path and speed.

The actual landing would be achieved visually with the aid of approach lights from about 100yd out. BEA believe that the techniques to allow completely automatic landing are already established, but their fixed-wing experience of approach couplers has determined this first stage of helicopter poor-weather operation. No one has yet carried out high-angle coupled approaches, although BEA's experience of manual approaches on 20° and 15° glide-slopes with Decca, Zero Reader and other equipment is probably unrivalled.

The approach aid itself, which would be duplicated in the helicopter, must be microwave in order to provide the required performance close to obstructions. There are other possible methods based on area coverage to allow complete freedom of landing direction, or even on three-dimensional area coverage, or cubic coverage with a system like Decca. It is reported that Pye Telecommunications are developing a microwave directional approach aid in conjunction with RAE; and BEA have themselves issued a specification for such a system. It calls for glide-slope angles between 10° and 20° transmitted over a 40° arc from the heliport. It must provide accurate guidance down to 100yd from the touchdown point, together with range measurement throughout the approach. For a fixed-wing aircraft following a flight path down to the runway, ground speed need hardly be assessed and airspeed is virtually a safety factor, but for helicopters groundspeed is far more important and range/rate information can be used to calculate it. Range is also the best parameter on which to base the timing of transition from one mode to another.

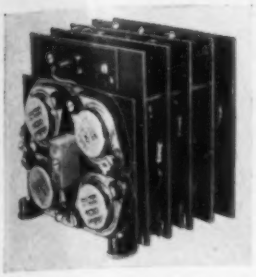
Fig 6 indicates the dimensions of an instrument approach at 15° glide-slope from a 500ft cloud-base down to the beginning of the flare-out at 100yd from the source of the approach aid. On the 15° glide-slope, the helicopter would be at 500ft some 1,870ft from the glide-path origin and, at 30kt, would cover the 1,640ft from a height of 500ft to a point 300ft from glide-path origin in 39sec. Assuming that the glide-path guidance is released at 300ft from the transmitter, the flare-out and transition would be started not lower than 77ft above the heliport. The helicopter would have to reduce a stabilized rate of descent of 650ft/min to zero and hover at about 20ft above the pad before touching down.

For a given approach speed and vertical g limitation (dictated by passenger tolerance), the height lost while reducing the approach rate of descent to zero would be directly proportional to the weight of the helicopter; and the greater the height lost the more accurately should the manœuvre be performed. A very large helicopter might have to begin flaring-out at 200ft, which would be 776ft and 15sec from glide-path origin.

Headwind or tailwind components would greatly affect groundspeed during the approach and therefore, also, the rate of descent required to make good the glide-slope. A 20kt headwind would reduce 30kt i.a.s. to a groundspeed of 10kt, requiring a rate of descent of 290ft/min and very small deceleration into the hover. An extreme opposite case, a 20kt tailwind, would increase groundspeed to 50kt and call for a rate of descent of 1,660ft/min followed by a correspondingly ample flare-out and deceleration. A 20kt cross-wind at 90° would cause 40° of drift. Because of the very much lower airspeed and steeper glide-slope, wind has a much greater effect on helicopter approaches than it does on fixed-wing aircraft. An approach at constant groundspeed, the measurement being made by integrating range signals from the approach aid, would therefore provide an attractive solution. These are the lines along which BEA are planning instrument approaches.

Westland proposal for a heliport over the Thames beside Waterloo Bridge. Two directions of approach along the river are possible and the site would have direct access to Charing Cross

"Flight" photograph



Above, left, experimental printed circuit modules for one stabilization axis of the new Newmark autopilot. Centre, Millimin packaging of a similar unit. Above right, the Westland Wessex, in which the 1N anti-submarine system produced by Newmark under Lear licence is installed

Louis Newmark Helicopter Autopilots

FOR some years Louis Newmark Ltd have been engaged in the design and manufacture of flight controls systems for both fixed-wing aircraft and helicopters. Their biggest project in the helicopter field has been to "anglicize" the Lear HSS-1N helicopter anti-submarine system installed in the Westland Wessex as the Mk 19 autopilot. Those features of the system which it is permissible to mention have been described in an earlier portion of this review. The 1N incorporates a large number of thermionic valves.

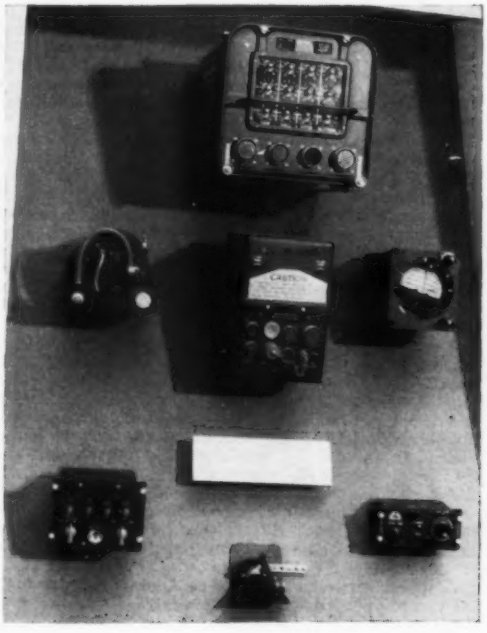
In conjunction with RAE, Newmark developed the Mk 14 autopilot for the Royal Navy and this equipment was evaluated in a Whirlwind both by RAE and Westland; and it is currently being used by the BEA Helicopter Experimental Unit as a basis for all-weather development. A brief account of a flight with this equipment appeared in *Flight* for January 8 last year. The autopilot provides short-term stabilization and attitude control in the pitch, roll and yaw axes, using rate gyros, together with additional yaw (or rather torque) compensation derived from collective-pitch lever position. Long-term flight path control using signals from a modified, panel-mounted artificial horizon and gyro compass can be added to the stabilization mode in cruising flight; and the heading lock is also applied in a hovering mode.

The stabilization mode relies on three rate-gyros from which both rate and "short memory" angular position signals are derived, so that the autopilot not only damps displacements but tends to return the helicopter to its trimmed position following a displacement. Pilot's control demands are superimposed on the stabilization with the aid of force sensers in the control runs, so that the pilot has a stable machine to manœuvre. In the cruise, or long-term attitude mode, trim controls allow small attitude adjustments to be made. In either the cruise or hover modes a disengage and manœuvre button may be pressed to return the autopilot temporarily to the stabilization mode while heading changes are effected. The autopilot is intended for helicopters with powered cyclic and manual yaw controls—presumably, therefore, for the Whirlwind—and the yaw servo provides some power assistance to the directional pedals. Stabilization, cruise and hover modes can be selected by a three-position switch on the cyclic stick and the system can be immediately disengaged or overridden.

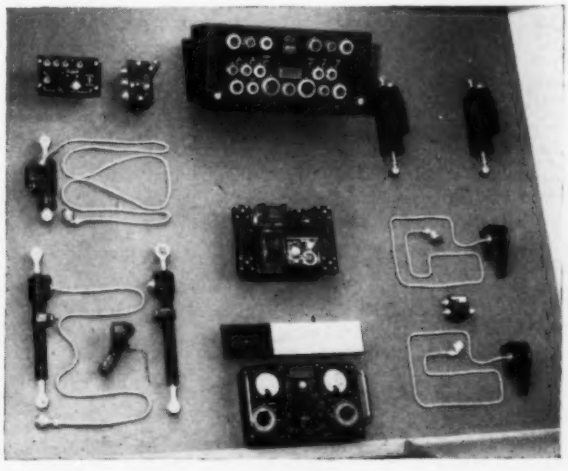
A height lock was added to this autopilot and experimental work is still proceeding, but Newmark are currently developing an entirely new lightweight autopilot based on plug-in, transistorized modules which are as far as possible standardized to perform the same function in any axis. "Parameter boards" with presetting facilities could make the autopilot quickly adaptable to various types of helicopter or to various types of control laws. Initially, three-axis stabilization and limited long-term control will be provided, with heading, height and speed locks, but approach and navigation couplers are to follow.

Either powered or plain mechanical controls could be actuated; and panel-mounted gyro instruments would be used, if available, to supply attitude and heading terms. Rate terms are taken from rate gyros. The accompanying illustrations show some of the experimental units so far produced on these general principles. Although Newmark are working principally on military contracts, civil requirements are being kept in mind and this type of equipment should provide a high degree of flexibility in installation.

From the point of view of equipment design, vibration is probably the most severe of the traditional environmental conditions to allow for. Vibration induced by rotors and blades is generally low, say up to 20c/s, but its amplitude is high—and much closer to the theoretical maxima stated in the specifications than is the case with fixed-wing aircraft.



Left, components of the Mk 19 autopilot of the 1N system. Below, the Mk 14 helicopter autopilot developed by RAE and Newmark
"Flight" photographs

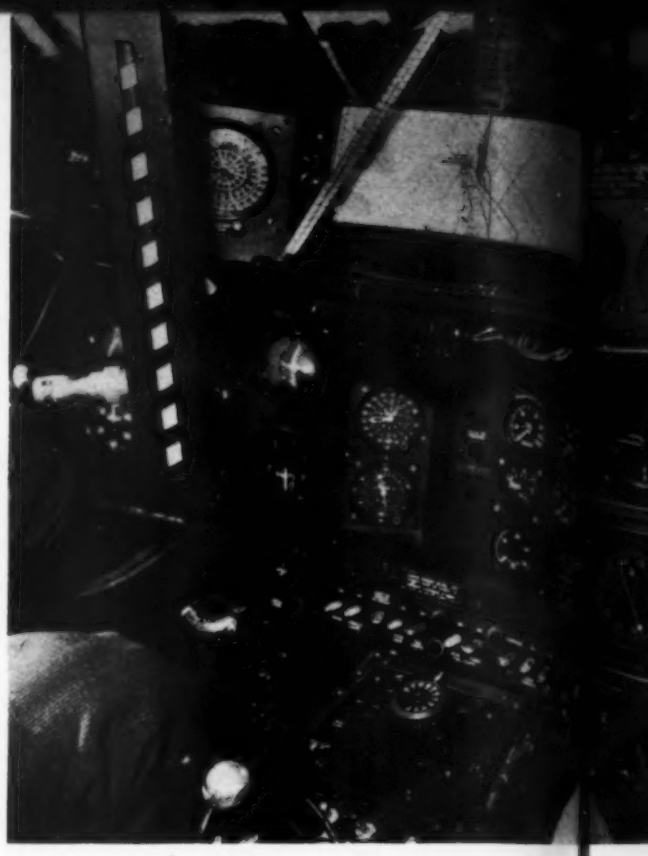


FLIGHT SYSTEM SURVEY...

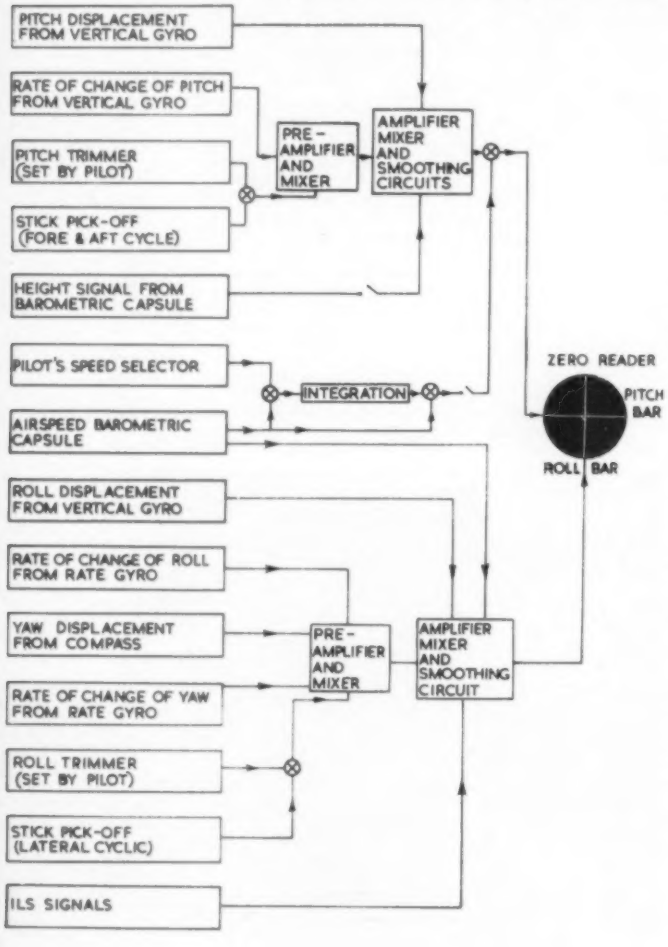
Sperry/BEA Flight Directors

BOTH in America and in Britain, the Sperry Gyroscope Co has, of course, been actively engaged in the development of instruments and autopilots for helicopters. For some years the company in New York has flown two S-55s extensively and at least one complete helicopter autopilot has been produced.

In Britain, Sperry have been working for some years with the BEA Helicopter Experimental Unit and MoA to solve the problems of flight-instrument design for helicopters and, through this, to investigate related control problems. Results of this programme were announced a fortnight ago. A working flight director system has enabled pilots—even those without previous helicopter experience—to fly the experimental Whirlwind successfully and accurately. A *Flight* representative, with limited helicopter experience (none of it on Whirlwinds), was able to fly the machine accurately in turbulent air without looking outside the cockpit; he changed speeds and made repeated turns demanded by BEA's experimental pilot Capt J. Reid.



Below, schematic layout of the information and computation channels in the Zero Reader flight director being tested in a BEA Whirlwind


PITCH DISPLACEMENT FROM VERTICAL GYRO
RATE OF CHANGE OF PITCH FROM VERTICAL GYRO
PITCH TRIMMER (SET BY PILOT)
STICK PICK-OFF (FORE & AFT CYCLE)
HEIGHT SIGNAL FROM BAROMETRIC CAPSULE
PILOT'S SPEED SELECTOR
AIRSPEED BAROMETRIC CAPSULE
ROLL DISPLACEMENT FROM VERTICAL GYRO
RATE OF CHANGE OF ROLL FROM RATE GYRO
YAW DISPLACEMENT FROM COMPASS
RATE OF CHANGE OF YAW FROM RATE GYRO
ROLL TRIMMER (SET BY PILOT)
STICK PICK-OFF (LATERAL CYCLIC)
ILS SIGNALS
PRE-AMPLIFIER AND MIXER
AMPLIFIER MIXER AND SMOOTHING CIRCUITS
INTEGRATION
PRE-AMPLIFIER AND MIXER
AMPLIFIER MIXER AND SMOOTHING CIRCUIT
ZERO READER
PITCH BAR
ROLL BAR

The Zero Reader was first applied to the Whirlwind as a basic two-axis attitude director with its computer modified to give not attitude directions, as it does in the fixed-wing application, but control demands, thus using the pilot virtually as an autopilot servo. Rate gyros and cyclic stick-position feed-back had to be added; and the helicopter could then be flown down to speeds slightly below cruising. The standard cross-pointer presentation and Zero Reader control panel were retained.

In order to extend the director function to speeds below minimum power value an extra element had to be added. Whereas at normal forward speeds cyclic stick movement would control height over an adequate range in the conventional fixed-wing way, the same control adjustment would be ineffective when following a steep glide-slope at low speed. Collective-pitch adjustment was necessary and a separate indicator was added beside the cross-pointers. At still lower speeds a similar yaw indicator was required; but, for the moment, a conventional ball slip-indicator is fitted above the Zero Reader.

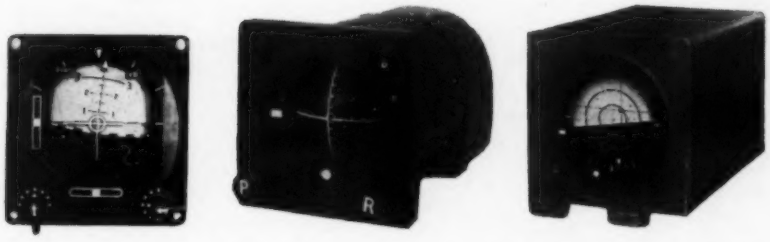
The four elements together are fairly "noisy"—someone jokingly said the pilot needs four eyes—but it is only necessary to follow all the indicators closely at the lowest speeds, and then only for short periods during a final approach. Working on similar lines, American Sperry produced the globe horizon and four-axis director illustrated here, but they did not find it acceptable, partly because the markings themselves introduced considerable clutter and partly because the instrument was being proposed for prolonged flying in the most difficult helicopter conditions. Furthermore, the dial itself was only of 3½in diameter, which is rather small for this type of application.

The block diagram on the left shows the elements incorporated in the Zero Reader portion of the Sperry/BEA flight director. The basic inner loop functions of stabilization are fed into the cross-pointers. Heading hold, preselected heading changes and ILS localizer signals, are additionally fed into the vertical pointer; and pitch terms for holding a barometric height or preselected speed are fed into the horizontal pointer. Long- and short-term control demands for cruising flight are therefore presented on one simple cross-pointer instrument, and the signals are suitably damped and filtered to make the demands extremely easy to follow. Turn demands are related to a constant rate of turn so that the maximum demanded bank angle is proportional to airspeed.

A separate vertical indicator channel has been added to direct the use of the collective-pitch lever at less than minimum-power speed, and in the first equipment the indicator is an early Smiths

climb angles. The fixed reference is covered in the picture by the moving cross-pointers. Collective-pitch and yaw indicators are incorporated and the arrowed knobs are for pitch and roll trim. Sperry and BEA hope to fly the roller blind director in the Whirlwind later this year.

Flight's conclusion after flying with the plain Zero Reader and PVD in the experimental Whirlwind suggested that, in a combined attitude/director instrument the director demands were rather more important than the attitude indications. First, the control-position demands of the director represented much tighter control of the pilot than the attitude demands in a fixed-wing machine and, secondly, attitude is less significant in a helicopter at fairly low speeds than it might be in a fixed-wing aeroplane. In the roller-blind instrument as illustrated, the attitude indication to some extent dominates the director dot. It seems likely that the dot will have to be made more prominent and the attitude presentation toned down, possibly by the use of two tones of grey rather than black and white. The relative merits of the collective-pitch scale and PVD for the same purpose will probably be determined to some extent by the distance the eye must travel from the attitude to the collective-pitch display, making allowances for the fact that PVD is extremely compelling even if it is removed some distance from the main display. In the experimental Whirlwind



BEA Whirlwind cockpit with Zero Reader (on the coaming), control panel (top right), Decca Navigator and early Smiths PVD for height control. Right are the Sperry New York globe-horizon helicopter director, the helicopter Zero Reader and the Sperry roller-blind helicopter director

PVD unit more than 12in high. In this instance the PVD is not really intended to be used in its true application as a peripheral-vision director, but its qualities in this direction could be extremely useful when the cross-pointers providing the stabilization terms are demanding concentrated attention. During the recent series of demonstration flights the Gatwick ILS glide-slope was not operating and the PVD collective-pitch director was therefore shown connected to a barometric height lock, which is its second application. One of its attractive features is that the pilot views two separate demand channels for his two separate controls, the cyclic stick and the collective lever. The division of channels appeared to *Flight's* representative to be logical and easy to follow. During an instrument approach, the pilot is quite distinctly holding the speed with the cyclic stick and Zero Reader and following the glide-slope with the collective lever and PVD.

In the experimental installation shown at Gatwick, the stick pick-offs and pitch channel have been made by BEA themselves. A radio coupler was taken from a Smiths SEP.2 autopilot and a speed lock from a pilotless aircraft was modified by BEA to cover a lower speed range. The height lock for the collective lever was taken from a Smiths autopilot. A fully engineered system could, of course, be made a great deal more compact and lighter.

The instrument display itself is also to be developed and Sperry have available the three instruments illustrated above. The first is a Zero Reader cross-pointer, incorporating vertical and yaw director indices respectively in the left-hand and lower edges. The knobs marked P and R are for pitch and roll trim. This represents a complete, single-instrument version of the equipment now being flown in the BEA Whirlwind. In the near future BEA intend to make a formal comparison between the meter and PVD presentation of collective-pitch demands.

It is a traditional requirement of flight director instruments for fixed-wing aircraft that attitude should be shown as a background to the director commands. Sperry have accordingly proposed the use of their roller-blind attitude director operated from a remote attitude gyro. The instrument has a large-diameter dial on which the external horizon is presented as a division between light and dark colouring on the roller blind viewed in relation to fixed rings and a dot on the dial face and fixed indices at the three o'clock and nine o'clock positions on the dial. Bank angle is also indicated by a moving pointer on the lower rim of the dial. Collective-pitch and yaw scales are on the left-hand and lower edge; and director instructions for pitch and roll appear as a moving dot suspended on cross-wires. The third picture shows the American Sperry 3½in dial with a two-colour globe horizon marked with dive and

the PVD was mounted well in front of the panel, about halfway between the pilot's eye and the Zero Reader, and therefore remained largely out of focus. Its indications were, however, unequivocal and immediate.

As a research tool the Sperry/BEA equipment has already proved its value, not only in the development of instruments but in the wider helicopter control field. The flight director can obviously be applied as an autopilot monitor and stand-by in a future BEA transport helicopter, but it would also serve as a simple system to give smaller helicopters adequate *en route* IFR capability when the cost and weight of a full automatic control system could not be justified.

This Vertol 44 is hovering under control of a Sperry autopilot. The pilot is holding both hands out of the window

FLIGHT SYSTEM SURVEY...

Ferranti Flight Director

WORK on a flight director for helicopters was begun by the aircraft equipment department of Ferranti Ltd as a private venture during 1958, but MoA endorsed their ideas and began to support the project during the following year. A flight director, or an autopilot, was evidently needed to extend the capability of the helicopter in poor weather; and a director would also become a requirement for monitoring the more capable autopilots.

It was realized that there was a fundamental difference between directors for fixed-wing aircraft, which made attitude demands based on the presumption of a safe airspeed, and a helicopter director, where no consistent "background motion" of the aircraft could be assumed. The helicopter director would therefore have to provide demands for control position, rather than attitude; and four axes—roll, pitch, yaw and vertical—were involved. A fifth function, engine power-control, was necessary if the powerplant/rotor combination was not automatically governed to run at constant speed or power.

A prototype of the attitude director was first exhibited at the SBAC display at Farnborough last year. Considerable test flying with an experimental director has been completed in a Whirlwind by RAE, which showed that even without autostabilization a pilot is able to fly the machine with considerable precision for more than an hour. The effectiveness of the system was substantially proved. A prototype of the navigation display which will form part of the director system is now almost complete and flight tests should soon begin.

The complete system includes the attitude and navigation displays, a vertical gyro from which attitude and pitch and roll rate are derived, an azimuth gyro giving heading and rate of change of heading and a control computer. An air-data computer giving height, speed and rate of change of these quantities is required.

The computer feeds the displays, but could also control autopilot servos. In addition, Ferranti are designing a coupler for radio aids such as ILS (or presumably, a helicopter equivalent), Tacan and Doppler in order to allow long-term flight-path control. An approximate block diagram is shown in Fig 1.

The attitude director, illustrated here, occupies a 5in × 5in panel cut-out. It has been made as large as possible in order to provide the maximum sensitivity without having to resort to unrealistic or non-linear indication. The aircraft silhouette traditional in artificial horizons has been replaced by a fixed datum ring in the centre and two pitch scales placed at the sides in order to leave the central area as free as possible. Attitude is represented by the relationship of the pitch scale and ring with the horizon bar. The scales cover a pitch range of ±5° to allow for attitude variations in steady flight. An adjustable datum for this purpose was considered undesirable, because of parallax errors and possible mistaken setting. A traditional bank-angle scale is at the bottom of the dial.

The director function is provided by a moving ring index supported on cross-wires and controlled in such a way that when the control column position is correct the ring index is centred and the helicopter is on or properly approaching the attitude required to produce the wanted flight-path.

The linear index across the top edge of the dial provides turn demands in the same sense as the slip-ball of the turn-and-slip indicator, but it controls long-term heading, the short-term corrections being fed into the director ring for correction by cyclic-stick movement. At speeds below about 20kt, all turns are made flat by yaw alone, and all turn demands are then fed into the yaw index alone.

Obviously, the vertical linear index in the left edge of the dial controls collective-pitch demand and is used during controlled descents on a glide-slope or for height holding. During an instrument approach, the speed demands would be fed in through the fore-and-aft cyclic demand and only height terms would appear in the vertical scale. Some collective-pitch demand would also appear during sustained turns, when the helicopter, like many fixed-wing aircraft, tends to lose height.

A single attitude and director combination, such as a horizon and Zero Reader, can keep a pilot fully occupied; and the addition of yaw and collective-pitch directors seem to risk making the display too "noisy" at times. The number and diversity of information channels requiring control reaction from the pilot are fairly high, so simplicity (which is the main purpose of a director) looks like being lost. Practical trials, however, seem to disprove this; and Ferranti point out that the attitude director will probably be used mainly to monitor autopilot operation, in which case the pilot has only to observe that all three director elements are centred. Hand-flying with the director in cruising flight would also be simplified, because then only the cyclic stick (and therefore the director ring) would be in constant use. As far as taking over manually following an autopilot failure is concerned, it is possible that only one channel or axis would fail, thus making it necessary to take over only part of the complete control task.

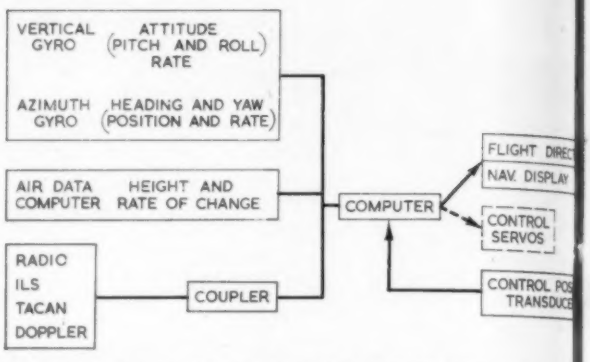
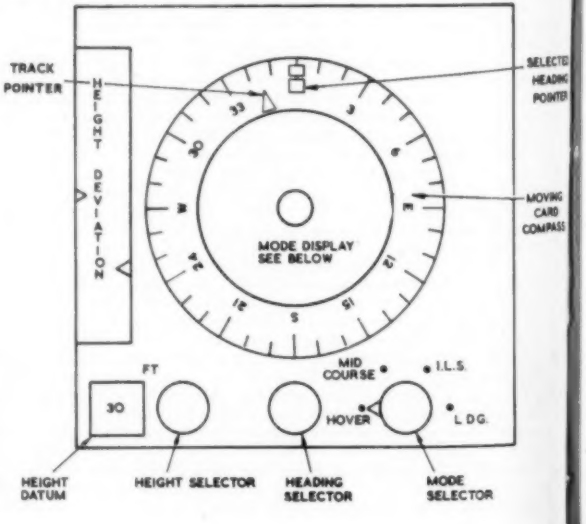


Fig 1, above, shows the schematic layout of the Ferranti director system. Top left, the attitude director instrument

The first trials at RAE with the four-axis director equipment, in a Whirlwind without autostabilization, showed that the pilot could fly blind for more thant an hour without fatigue and with great accuracy. Pitch attitude was in fact held to within ±1° and the results were directly comparable with those achieved by an autopilot. The main difference was that the autopilot's control movements were sharper than those of the human pilot using the director. The first engineered version of the director attitude display, complete with the first navigation display and computer, should be test-flown during the next few months.

While the attitude director tells the pilot where to move his controls, it can tell him little if anything about the flight path his aircraft is following. This is the function of the navigation display (Fig 2) which is a situation indicator and not a director. It also provides controls with which the long-term flight-path parameters

Fig 2. The navigation display with its rotating compass card, height deviation scale and control knobs. The four different roller-blind displays which can appear inside the compass ring are shown overleaf



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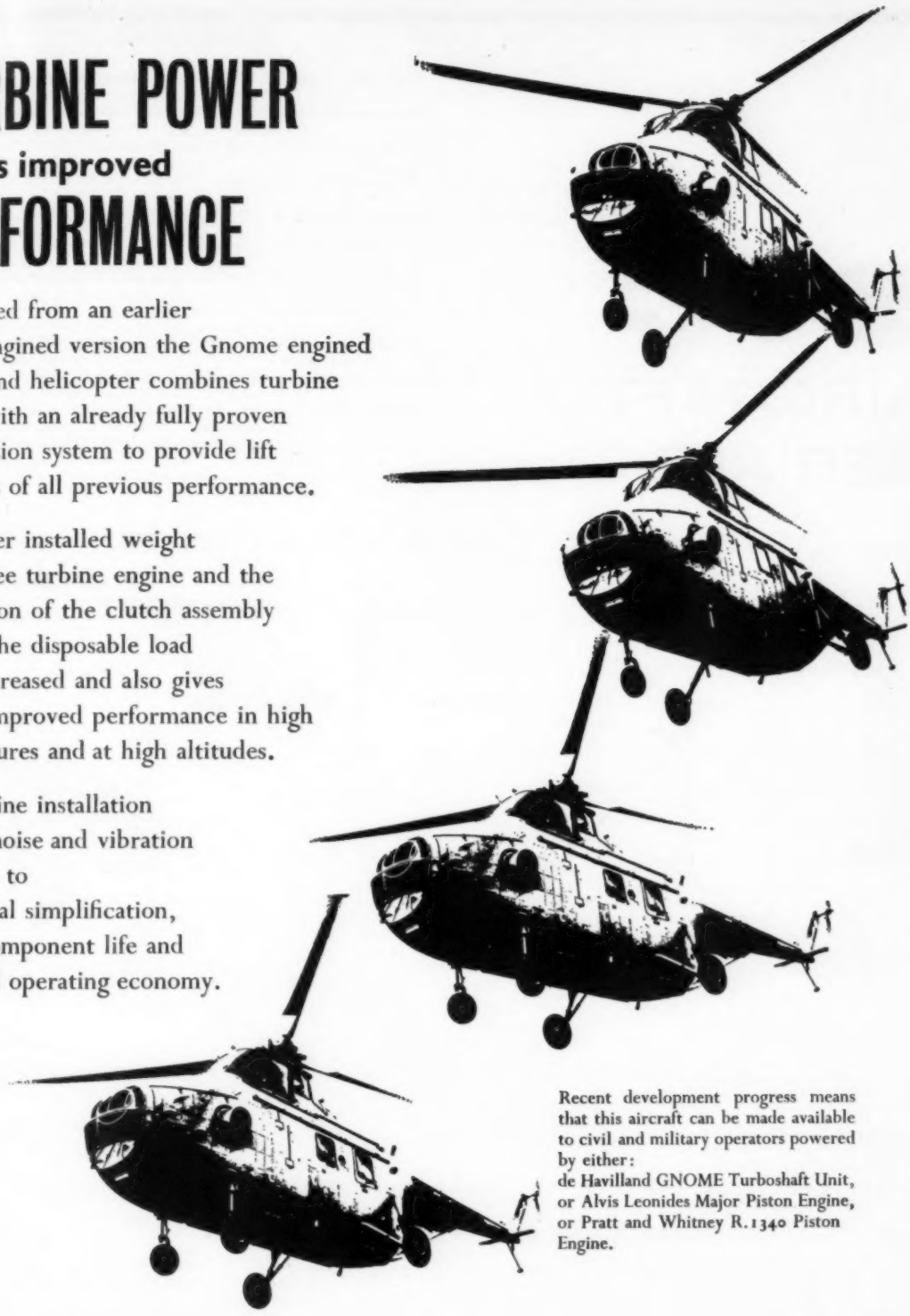

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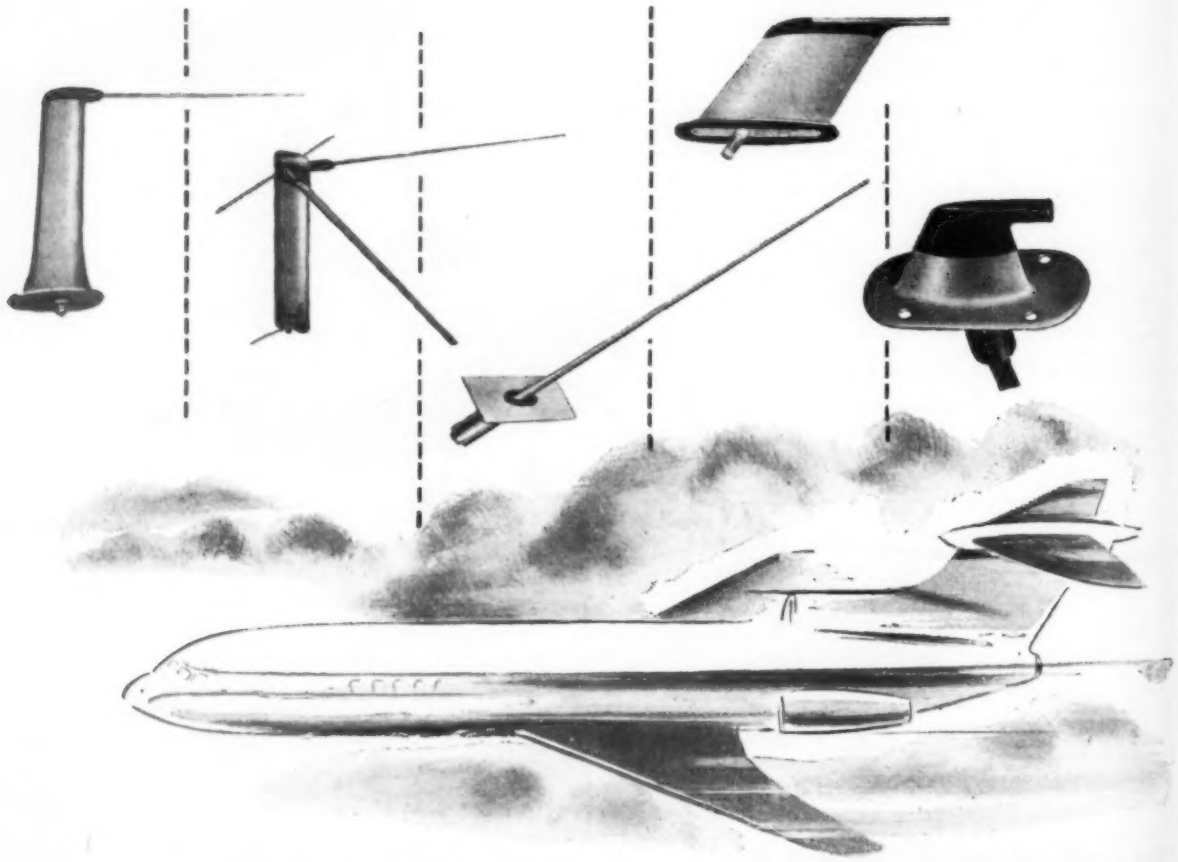

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SYSTEM SURVEY...

may be set up. Basically, the Ferranti unit is rather like the navigation display of the Smiths roller blind Flight Data System for fixed-wing aircraft. It has a rotating compass card surrounding a plan-position display made up of roller blinds which can be positioned relative to the central fixed datum ring for four different modes, mid-course navigation, ILS, hover and land. The mid-course display, Fig 2c, provides range rings and bearing information. For ILS, Fig 2d, the arrow-shaped pointer appears and provides not only angular but positional information relative to the localizer beam. Glide-slope displacement is shown on the height deviation indicator on the navigation display. Collective-pitch demands for glide-slope following appear beside the attitude display. There is a possibility that a glide-slope needle on the navigation plan-position display could appear almost parallel to the localizer arrow in cross-wind landings with high drift.

Simulator trials by the Institute of Aviation Medicine indicated that a suitable type of pattern for a hovering display was the rectangular lattice pattern shown in Fig 2b. It is formed in the instrument by two roller blinds—the upper one being transparent—each carrying a set of parallel lines. The lattice has no geographical significance and is related only to movement relative to ground or water surface. It naturally depends on Doppler signals for its surface contact. The purpose of this mode is to tell the pilot, as he monitors the autopilot, exactly when the helicopter is stationary. After he has pressed the hover demand control of the autopilot in forward flight the transition begins, but he has no indication when he is actually hovering. The compass ring will continue to indicate his heading; and the track pointer on the compass card will show the Doppler-derived track.

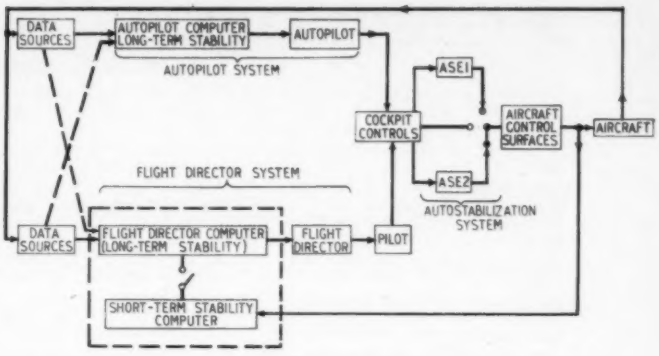
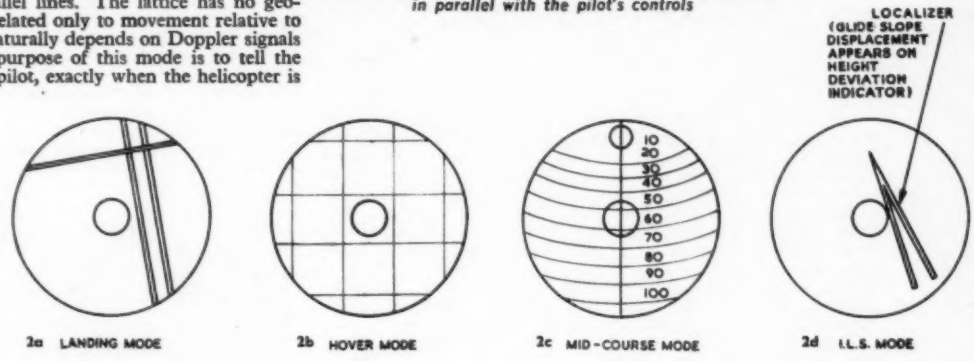


Fig 3. Schematic layout of combined flight director and autopilot with duplicated automatic stabilization equipment. Stabilizer inputs are in series and autopilot inputs in parallel with the pilot's controls



Figs 2a, 2b, 2c and 2d show, respectively, the landing, hover, mid-course and ILS modes for the navigation display

The landing display, Fig 2a, is intended for operation with a precision approach aid giving both centre-line and range information. The parallel "tramlines" would indicate position relative to the approach centre-line (localizer) and the single transverse bar would indicate range from the touchdown point. Tramline and range bar always remain at right angles to each other and where they cross represents the touchdown point. The range signals are linear so that some range-rate information can be derived.

Beside the compass dial is the height deviation scale and, below, the height datum setting, the purpose of which is self-evident. The scale is long enough to provide some rate information and it is possible to tell when the helicopter is settled at a given height. Radio altimeter, Doppler height sensing or barometric altimeter would provide the basic information.

If a flight director is to be used for monitoring an autopilot it is obviously necessary that both systems should produce the same control demands at any moment; and the computers for the two systems will therefore be very similar if not identical. Ferranti might therefore contribute to the helicopter autopilot field with an integrated instrument and control system in which individual data sources could be arranged to feed either of two computers, one serving the flight director and the other the autopilot. Duplicated autostabilizers with a changeover could be integrated with the control system and an advanced degree of duplication and standby would result. Fig 3 shows a layout of this kind.

All-weather Helicopter Research in the United States

IN terms of time and resources, the American helicopter and instrument manufacturers, the Services and the Federal Aviation Agency are all some way ahead of their counterparts in Britain in achieving helicopter instrument flight and all that goes with it. Particular examples are the helicopter anti-submarine systems such as the 1N, by Lear, and its successor the 2N, being developed by Hamilton Standard; the FAA helicopter operations programme, now well into its second phase; and the extremely ambitious and uninhibited thinking involved in the helicopter portion of the Army/Navy Instrumentation Programme (ANIP) for which Bell Helicopter Co has the co-ordinating authority.

Phase I of the FAA helicopter programme was designed to produce an initial estimate of the problems of operation in and around a large city, with emphasis on the navaid to be used. All five of New York Airways Vertol 44Bs were fitted with Decca Navigator, which was operated for some months during normal passenger-carrying flights. NYA did not, however, depart from its VFR, map-reading type of flying. New York is a very-high-density air traffic area, it has weather which varies from heat-wave summers to blizzard winters, and it includes ground obstructions about as high as are likely to be found anywhere. The final report

FLIGHT SYSTEM SURVEY...

on Phase I was published by FAA late in 1959 and included a detailed, independent evaluation of Decca performance by Airborne Instruments Laboratory Inc.

Among the general conclusions resulting from the programme were that helicopters would, for reasons of operating economy, have to keep clear of fixed-wing traffic areas and that they would probably have to operate below airways in a rather confined airspace band between 1,000ft and 1,500ft. Height separation between helicopters, and obstacle clearance, would be reduced below fixed-wing levels. Helicopter airways would be much narrower than the ten-mile width allowed for fixed-wing aircraft; and one-way routes might be employed. It was stressed that helicopters would operate among and not necessarily above obstacles and that they therefore required a very precise area-coverage navigation aid capable of operating below line-of-sight. The existing "common system" VHF and UHF aids would not be adequate. Curved flight-paths might be flown, rather than sequences of straight legs.

Helicopters entering a terminal zone in cloud would probably have to let down to a fringe heliport and continue visually to the city centre at low altitude. Eventually, all heliports which were sufficiently unobstructed might have their own precision-approach aids. Ultimate IFR minima were stated to be 50ft ceiling and one-eighth mile visibility, using outline and approach direction lighting to assist final landing.

The whole traffic-control problem in an area like New York was that of being able to direct a large number of machines in a very restricted area, and a much higher data rate between helicopters and ground controllers would be necessary. Airspeeds would have to be restricted in the high-density areas—high speed meant little in terms of journey time over very short routes—and the best cruising speeds of between 150kt and 200kt would only be feasible on the longer *en route* sectors. The background to these considerations was a predicted "explosive increase" in helicopter travel during the next decade; the Port of New York Authority estimated that by 1975 more than 6,000,000 people would be arriving at or leaving Manhattan by helicopter every year.

The helicopter operations programme was not solely concerned with civil operations, but was also intended to provide all kinds of practical information for the services and manufacturers as well. One of the problems was that of pilot qualification. There is as yet no civil instrument rating for helicopter flying, either in Britain or in America, but the US Navy and Army have cleared some types of machine for IFR operations and run training courses in instrument flight. Ratings are issued, but they are subject to certain restrictions because of the variety of operating techniques involved in different types of helicopter. This represents a problem which civil authorities have yet to solve.

The FAA has hitherto certificated helicopters under CAR.3 for fixed-wing aircraft, with certain relaxations in stability and control requirements based on the "state of the art" in helicopter design. It went a stage further with the Cessna CH-1C in issuing an IFR certificate based on control characteristics which would allow the machine to be flown in cloud using conventional instruments with adequate safety in case of various malfunctions. Cessna produced some remarkable stability and trim devices employing pneumatic bellows sensing air pressure and engine intake-depression and rate gyros driven by the transmission working in series with the roll and pitch-control linkages from the cyclic stick. Flight in cloud and in moderate icing, and approaches under various degrees of instrument and electric failure proved the CH-1C to be capable of conventional instrument flight in most conditions. But even this only covers the handling side of IFR certification.

The Phase I FAA operations programme involved only VFR flying, because of the single-engined helicopters which had to be used. It was therefore decided to run Phase II with multi-engined military machines operating over selected routes on a scheduled basis, the pilots flying actually in cloud or "under the hood" all the time. A special FAA traffic-control centre was set up and the routes were arranged to run right across the New York area with lateral or vertical separation, as appropriate, from fixed-wing airways. Flat and hilly country, water, multi-airport terminal area and a large airport in a high-density area (Idlewild) were involved.

Two Sikorsky H-37 twin-engined helicopters fitted with duplicated Decca Mk 8 receivers were to be operated initially, with US Army and Marine crews but, as the programme progressed, every kind of multi-engined helicopter and navigation aid were to be added. Both Vertol and Omega types were to participate; and most of the support from the Services and from industry was to be given free of charge.

The Cessna CH-1C which, with novel stabilization devices, has been cleared by the FAA for operation in cloud

The Boeing Vertol 107 prototype landing at the new Wall Street heliport in New York. This and the view on the previous page show the kind of area in which helicopters may have to operate in poor weather

Well over 600 hours' flying were completed during the last eight months of 1960. Unfortunately, a recent *Flight* request to the FAA for information on Phase II met with the reply that nothing can be said before the final report is completed on June 30. Nevertheless, the effort and resources involved are considerable and should provide some significant conclusions. It is a pity that nothing remotely comparable has recently been attempted in this country. Neither the hardware nor, apparently, the official support, are available to attempt operational trials on anything like an equivalent scale.

The Esoteric Approach While the helicopter operations programme is a relatively down-to-earth attempt to define and resolve the immediate operational problems, the vast ANIP programme is seeking long-term solutions by completely uninhibited thinking. As co-ordinator of the helicopter (and VTOL) side of ANIP, Bell Helicopter Co built a mighty flight-simulator and modified at least two helicopters to carry extensive research equipment. The simulator is intended to be able to reproduce the manœuvres, sound and vibration of any type of helicopter and has a moving-base structure designed by the Franklin Institute. Among the many types of equipment mounted on it was the actual cabin section of the HTL-7, which has been called Research Helicopter 1 and in which a contact analogue display and visual projection techniques have been tested. Research Helicopter 2, a Bell HU-1A Iroquois, has been fitted with equipment leading up to the present flight director and navigation system incorporating the Remote Area Instrument Landing System. Microwave RAILS and an interim ANIP display using cathode-ray tubes have been installed in a US Army H-37 and were being delivered for trials this month.

The whole ANIP programme involves literally dozens of different lines of investigation into every subject connected with

Twin-engined Sikorsky S-56. An Army and Marines version of this type have been flying the Phase 2 FAA helicopter programme involving scheduled IFR flights in the New York area

information presentation and aircraft operation, but the three projects listed above are the main examples of workable systems which have so far emerged on the helicopter side. They are based almost solely on military requirements and involve equipment of considerable weight and great complexity. Their interest to civil passenger operations is therefore fairly limited at present, although Bell are tentatively offering a simplified civil version.

These developments follow early work during 1956 and 1957 using Decca Navigator, Bendix sonic altimeter, a Kenyon ground-movement indicator, ILS and conventional horizon and gyro compass. Little information has ever been released concerning the Kenyon device, but other hover and landing instruments have followed approximately the same display principles. The Bendix sonic altimeter has been evaluated by New York Airways, BEA and other companies, and has proved accurate to ±6in at heights up to about 150ft. It involves echo ranging from 3kc/s sound pulses directed at the ground, but unfortunately its range is relatively limited. The pulses are also distinctly audible on the ground and sound disconcertingly like machine-gun fire to uninitiated bystanders.

In the development of hovering displays Bell have employed an ingenious and very simple ground-sensing system based on fore-and-aft and lateral cables held by men on the ground, passing over large wheels attached to the helicopter. As the aircraft moves over the ground, the cables are held firm by the men and therefore cause the wheels to rotate. The motion is sensed in the helicopter and displayed on the instrument being tested. Height is similarly directly derived from the angle of a sprung pole hinged at one end beneath the fuselage and with its other end resting on the ground below.

The principal project with the RH-1 helicopter was the development of the Autonetics contact analogue and collimated projection technique using a partially reflective glass screen. It was necessary that the screen itself should cause no attenuation of the shape and colour of the exterior scenery but that it should also clearly reflect in almost any ambient light conditions the patterns and indications of the contact analogue optically projected from a cathode-ray tube. The result of intensive research is the trichroic combiner in which special multiple optical coatings have been applied to a shaped glass lens in such a way that the lens reflects pure green but remains transparent to other colours. The greens in trees, grass, paints and lights contain considerable elements of blue and yellow and it was found that the human eye very rapidly accommodated itself to the loss of the small pure green element and could increase its sensitivity sufficiently to reconstitute the colour in the visual image. It was found to be essential that the display should be collimated.

Bell proposed this method for use with a contact analogue generator produced by the Autonetics division of North American for the experimental HTL-7 helicopter used in the ANIP programme. Optical Coating Laboratories Inc of Santa Rosa, Calif, developed the special coatings and the method of depositing them so that they are now hard and water-resistant. They have succeeded in programming IBM computing equipment to determine rapidly the complex composition of the multi-layer film stacks required for various applications. Initial stress-cracking problems have been overcome and the transmission or leakage in the rejected colour band has been reduced to less than 0.1 per cent. The coatings now used have even less absorption than conventional interference filters and the latest film stacks show an appreciable reduction of shift in spectrum response as the angle of incidence is varied.

The contact analogue is generated in the CRT in green; and almost any pattern or instrument indication can be projected. It has also been found possible to allow a large tolerance in the angles from which the display can be viewed. Investigations now in hand seem to indicate that tetrachroic and pentachroic combiners will in future allow the projection of two- and three-colour displays. Preliminary studies, Bell claim, hold promise of full-colour, high-contrast displays presented on the trichroic combiner now used for the single-colour patterns.

Optical Coating Laboratories found from their own earlier work that there seems to be no real limit to the angular span of the display and the main problems lie in the production of uniform high-quality trichroic coatings over large areas and in the design of unique projection optics. Also to be overcome were the effects of vibration in an installation where the optical elements were mounted on separate parts of the aircraft structure. The display can be used in both day and night conditions; and a red filter can be applied so that the display appears red for night flying.

In addition to the display system, the RH-1 was fitted with Ryan APN-97 Doppler and the sonic altimeter; and the contact analogue was the minimum pattern which could be used for blind flight. The object was to check the basic system.

In the HU-1A designated RH-2, Bell installed first a Bendix Pacific all-purpose radar and then a complete navigation computer and instrument display for more advanced flight tests. The Bendix radar was a Ku-band, mono-pulse unit with an aerial mounted above the cabin. It was capable of providing at the same time ground-mapping information, terrain clearance and height above ground. Terrain clearance could be shown in the form of a two-colour display on which all objects below the flight path were shown in green and all those above, and therefore dangerous, in red. Bell have devoted a great deal of study to the assessment of the type of visual representation of obstacles which would best suit the pilot. One result is that the degree of definition of objects in the flight-path is related to their range and closing speed from the helicopter.

Relevant outputs from the Bendix radar were fed into a central digital computer, but inertial information from two 20°-of-freedom gyros, contact information from an APN-119 Doppler and position information from two Decca Navigator receivers

Bell's Research Helicopter 1, an HTL-7, fitted with contact analogue, Bendix sonic altimeter and Ryan APN-97 Doppler

FLIGHT SYSTEM SURVEY...

were also accepted. As well as navigation information, the computer produced range and endurance calculations, maximum permissible normal acceleration, ETA, hovering time available, wind velocity and autorotative landing radius.

One of the main military objectives has been to be able to operate helicopters in open country and to land at any chosen spot regardless of weather. To a certain extent this was achieved by the use of the early Decca and ILS equipment in 1957, but even the three ground stations of a two-pattern Decca chain were too large to install for some of the more extreme tactical applications. Bell accordingly developed MWRAILS, mentioned earlier. The ground equipment is essentially a battery-operated transponder, weighing only 15lb, which can be easily set down almost anywhere and has a range of about ten miles. It can operate for about two days and, once interrogated, it will switch off again if interrogations do not continue after a certain time. It can therefore be set up and left virtually unattended for considerable periods.

All the actual approach calculations are done by an interrogating radar and computer in the helicopter which measure the azimuth, elevation and range between helicopter and beacon. From this, groundspeed, glide-path angle, course, height and other factors are calculated and the information is presented on a special flight director display. Because the beacon is microwave, its signals can only be received by the aircraft if there is no intervening obstacle and a form of obstacle clearance is thus provided.

A contact analogue pattern reflected from the trichroic combiner in a cockpit mock-up. The full equipment is below

The trichroic combiner installed in Research Helicopter 1. Amber screens are mounted in the bubble for simulated blind flying

Bell's Research Helicopter 2, an HU-1A Iroquois, with the fairing for the Bendix Ku-band, mono-pulse all-purpose radar above the cockpit

MWRAILS has been incorporated in the Interim Integrated Aircraft Instrumentation and Letdown System which is now being delivered to the US Army for evaluation. The test aircraft, a Sikorsky H-37, has autostabilizer and throttle control, radio altimeter, Ryan Model 120 Doppler and a dead-reckoning computer. To this, Bell are adding their cathode-ray tube instrumentation, which is the interim ANIP system of attitude/director and navigation displays. The attitude instrument has a moving aircraft symbol (outside-in display) and director ring and a height display consisting of a dark area which moves up the screen as the helicopter loses height. Two height scales, 0-1,000ft and 0-300ft, can be set and the correct hovering height is attained when the dark area reaches a certain level on the tube face.

The navigation display has a fixed central dot representing the helicopter. The direction of flight is given at the twelve o'clock position on a moving compass card round the display; and the relative plan-position of the RAILS beacon is shown as another dot. A straight line passing from the fixed dot, through the beacon dot to the compass card shows the bearing of the beacon and range marks indicate its distance from the helicopter. Range scales of 60,000ft (ten miles), 3,000ft, 300ft and 30ft can be selected; and the whole approach path is calculated by the central computer and translated into control commands to make good the approach. Groundspeed is indicated by a rectangular grid which forms a background to the navigation display. When groundspeed is correct, the grid is stationary, but it moves to direct an increase or decrease in speed if necessary. The direction of movement is in a command sense, like the indications of a Smiths PVD. Landing accuracy is reported to be 20ft, or half the rotor diameter of the helicopter.

In addition to the two cathode-ray tubes, there are vertical tape instruments to give quantitative flight information, a fuel/range/endurance display and simplified engine instruments. When using RAILS, the pilot can elect to land at the beacon or at a point offset from it, and the indicated range scales change automatically as the helicopter approaches touchdown. RAILS beacons, Decca or other aids can be used for *en route* flying and Bell claim that a complete flight from take-off to landing can be programmed before take-off and carried out blind. They also claim that pilots with only 12min familiarization have accurately flown the helicopter.

This interim system certainly represents a very large step forward from the military point of view. The ground equipment is very small and compact and could even be distributed behind enemy lines. But, from the civil angle, where payload is of primary importance, it is rather wasteful to install so much of the approach equipment in the helicopter itself. The merits of the actual display symbols are also open to question, but could be relatively easily changed now that the basic development has been completed. Bell themselves proposed at one time that the cathode-ray tubes should be replaced by electro-mechanical displays when the symbols had been approved, although they had experienced very high reliability in other cathode-ray tubes installed in helicopters.

Even if the very considerable research carried out by Bell has no immediate civil application, the knowledge gained and the equipment developed must prove extremely useful at some future date.

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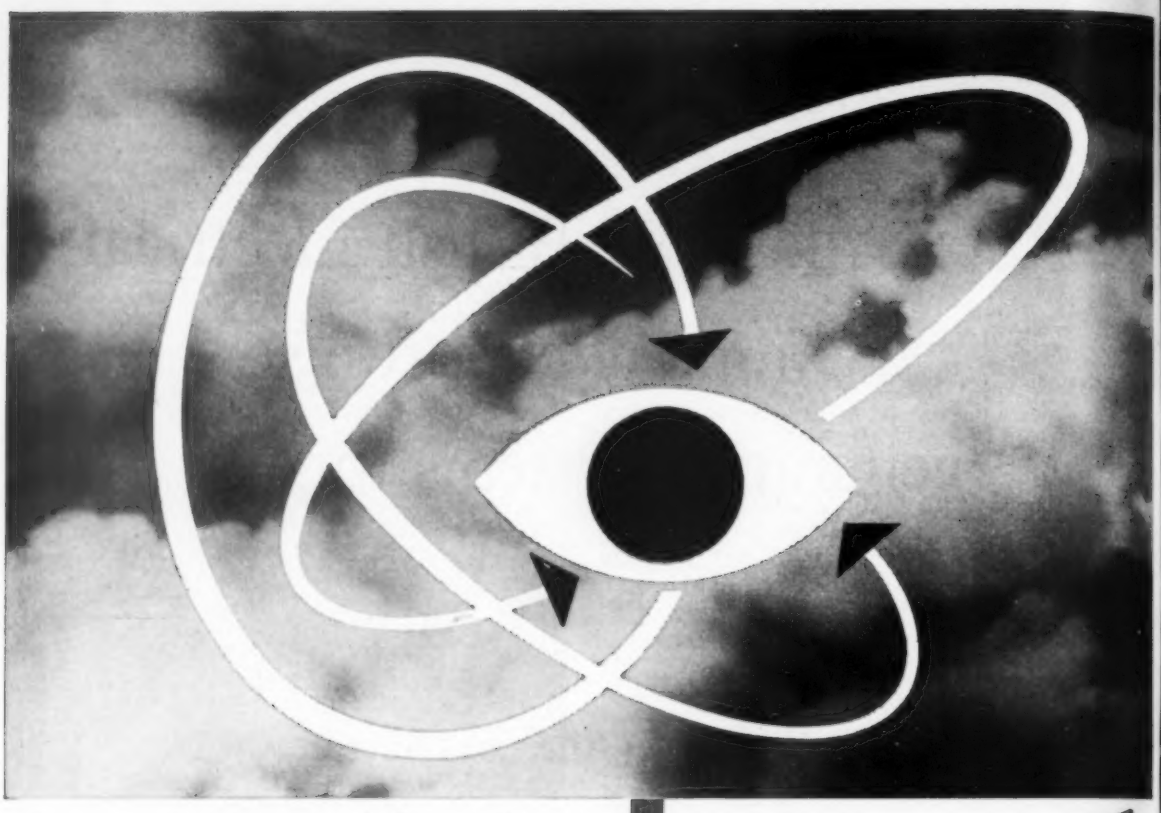

eye on the sky

WITH SECONDARY RADAR

Cossor is at present manufacturing a complete L band system of Secondary Surveillance Radar for Air Traffic Control.

The System consists of a ground interrogator-responsor equipment and an airborne transponder.

Use of this equipment, of which Cossor are the only manufacturers in Europe, enables a great deal of identification and flight information to be presented automatically, thus providing an invaluable aid to air traffic controllers and an extension of primary radar systems.

The system's characteristics have been laid down by I.C.A.O., and the airborne equipment, complies with the ARINC characteristics which are applicable. The ground equipment is manufactured to a specification issued by the United Kingdom Ministry of Aviation.

Because secondary radar does not rely on reflection of energy, a range of about 200 nautical miles is achieved with quite modest transmitter powers.

'Sidelobe suppression', pioneered by Cossor engineers, is incorporated: this eliminates sidelobe interrogations which otherwise cause confusion on the display and reduce the probability of transponder saturation.

Cossor transponders are at present being fitted in all the BOAC Boeing 707 jet aircraft.

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SYSTEM SURVEY

Control panel for transmission and reception of messages by AGACS data link

Data Link for Traffic Control

BY R. F. WILLIAMSON*

FOR some years all those concerned with air traffic control have devoted considerable effort to increasing the efficiency of the system by improving equipment, techniques and operating procedures. Among the many factors which make such development urgently desirable are the rapid increase in air traffic density, the large number of near misses which are reported, the tight economics of modern jet operation and, not least, the incidence of a few tragic accidents with their attendant publicity. In the main, recent effort has been directed towards improving the techniques of acquiring data, and then applying and processing it, in order to perform automatically some of the functions of the air traffic controller. Rather less emphasis has been placed on the development of a suitable communication system, although this is nevertheless a vital part of traffic control. The communication system must be much more sophisticated and speedy if it is to meet the requirements of the automatic system into which it fits.

The data link—if by that term we mean an automatic or semi-automatic, coded system of data exchange—is by no means the total answer to the communication requirements of the ATC system of the future. Much depends upon the degree of automaticity which is considered suitable and the speed at which evolution takes place. Conventional communication techniques such as radiotelephony are certainly not excluded.

As one would expect, there are many points of view to be considered when system philosophies are formulated. On the one hand, there is the electronics expert who envisages a completely automatic electronic marvel, untouched by human hand, gobbling input data at one end and issuing firm instructions at the other. On the other, there is the traffic controller who quite naturally wants to see with his own eyes and hear with his own ears what is going on, to assess the situation, and to make the necessary decisions. Often overlooked is the viewpoint of the pilot, who is usually just looking for better communications and some relaxation of his not inconsiderable workload. He is wary of being confronted in his "office" by an electronic monster which he may not be able to tame. To the airline operators workload is of considerable significance, particularly on the short-haul routes, where so much has to be done in such a short time.

Among the advantages which it is hoped will accrue from the use of automatic and semi-automatic communication systems are workload relief; more frequent contact between ground and air; more efficient use of available frequencies; more reliable long-range performance; the ability to feed data directly into and out of computing systems; an increase in the air traffic controllers' handling capacity; and elimination of fixed-point reporting.

It is unfortunately true that no real agreement has yet been reached, either nationally or internationally, on a co-ordinated communication system concept. By far the greatest amount of system thinking and hardware design and evaluation has taken place in the United States. This is in no small measure due to the fact that the air traffic control problem there is so much more acute than elsewhere. Quite naturally, the analysis of system design which has so far been carried out in the US has been directed more particularly to the problems of the American environment than to those of the more general situation. There has probably been considerable development work on allied systems for military purposes both here and the United States.

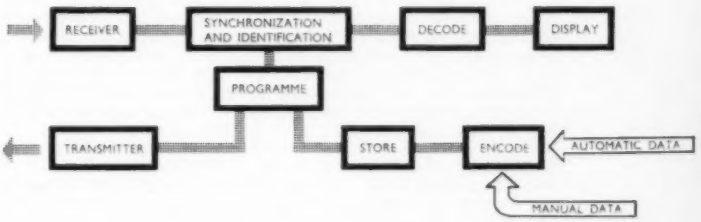
The private pilot has a particular interest in the provision of automatic communications, inasmuch as he must be included in the overall traffic control system. He wants the advantages of automatic communication but, obviously, he is not prepared to pay for the same kind of installation that might be fitted in a large civil airliner. Again, in the United States some work has been done and systems have even been produced for this purpose.

The factors which affect system design are numerous and some of them complex within themselves. As is usual with system design, the final form is a compromise between the conflicting requirements of its component parts. The main factors to be taken into account are range requirements; time or frequency division multiplexing; information data rate; frequency; bandwidth; methods of modulation; number of aircraft to be controlled; frequency of communication; degree of "fail-safe" required; and susceptibility to interference.

To some extent, the range requirements of the system will determine the frequency spectrum to be used. For ranges of up to 200 miles or thereabouts VHF or UHF is much to be preferred. For long-distance communication lower frequencies must be used, probably in the HF band between 2 and 22Mc/s. In the very-low-frequency bands quite reliable long-distance communication is achieved, but it is not easy to radiate from aircraft on these frequencies. It is perfectly reasonable to receive ground-to-air transmissions. The effectiveness of such communication has been demonstrated by the long-range, low-frequency teleprinter service to be described later.

System performance is much affected by the frequency used for transmission. In the high-frequency bands the pulse length used must be kept relatively long in order to avoid ambiguity and errors caused by deformation of the signal during transmission. It is generally thought that a pulse length of around 20microsec

*Cossor Radar & Electronics Ltd.



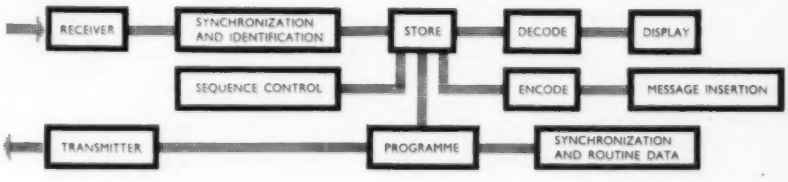


Fig 1, upper right, and Fig 2, right, show respectively the possible layout of airborne and ground units of a roll-call data link system

Fig 3. Airborne data input panel for the RCA data link called AGACS

FLIGHT SYSTEM SURVEY...

is the optimum for reliable HF communication; and this means a bit-rate of 50 per second—quite a low-speed system. Such propagation problems are much less significant at the higher frequencies and higher speeds can therefore be employed.

Time division multiplexing is normally preferred to frequency division because of its channel economy; but even with a time-division system, some degree of channel duplication will normally be necessary if signals must be separated according to sectors, height layers or other factors. With time-division multiplexing, selective communication is achieved by allocating each aircraft an identity code which it must actively recognize. Ground-station radiation will probably be omni-directional, and it is convenient to call all the aircraft involved in turn—sometimes referred to as the "roll call" system. Figs 1 and 2 show schematically a possible system layout.

The interrogation time-cycle and the number of aircraft to be controlled will determine the data rate and hence the bandwidth of the system. The range requirement, message content and interference susceptibility will to a large extent limit the choice of frequencies and modulation techniques.

In systems using common timing each transmission must be prefaced by a synchronizing pattern, probably followed immediately by the identity code. If the aircraft recognizes and accepts the identity code the remainder of the message can be decoded and displayed. The reply system will then be triggered to transmit a message whose content has been preset either manually or automatically.

The type of data display and insertion equipment used in the aircraft is of vital importance and calls for careful application of human-engineering principles. There are many ways in which message data may be displayed, but there is a tendency now to favour tape print-out rather than volatile displays, in order to provide the pilot with a more permanent record. The complexity of the airborne insertion equipment will depend largely upon the degree of flexibility required of the system, but it should obviously be kept as simple as possible.

The complexity of the ground equipment again will depend on the degree of automaticity required. The rate of return of communications from aircraft in a roll-call system is such that the traffic controller cannot possibly examine data as it arrives, although it can be fed to a computer at that speed. There must be an information store of some kind from which the controller can extract and examine the messages previously transmitted to and received from any particular aircraft.

It is obvious that there are tremendous operational as well as technical problems in introducing these automatic techniques, and they must be phased-in gradually in an evolutionary rather than a revolutionary manner.

Both in Britain and the United States several systems have been developed, which are capable of transferring data either in one direction or both. No one of these systems is a complete answer to the communications problem, but a co-ordinated complex might well include any of them.

R.C.A. Automatic Ground/Air/Ground Communication System (AGACS) In the United States the FAA has for some time carried out a considerable programme of system study and analysis. In 1958, R.C.A. were commissioned to produce an experimental time division multiplex system to conform to parameters laid down by FAA. This equipment has been made and subjected to an extensive flight testing programme. The information so gained will be used to assist in further stages of development. It is intended that it shall feed data to and receive data from the ATC Data Processing Central which has been developed and produced by General Precision Laboratories. In the aircraft the equipment consists of the black box containing the data processing equipment and a data insertion and display panel in the cockpit (Fig 3). Each direct read-out display is cancelled and replaced by succeeding messages, but will probably be backed up later by a print-out device. The pilot inserts data by selection of one of 32 predetermined messages with qualifying data; and this is transmitted immediately upon receipt of the next interrogation from the ground. The basic ground equipment feeds a direct read-out display via a magnetic store which holds the last received message from each aircraft on the roll. The controller can select any one of these for display, and composes a suitable reply for transmission. There is provision for voice override in both directions.

The AGACS communication system utilizes frequencies in the VHF and UHF bands and, because up to 500 aircraft must be controlled and contacted at intervals not exceeding two minutes, the bit-rate has to be of the order of 750/sec. Messages of approximately 70 or 80 bits can therefore be passed each way. VHF and UHF single-channel simplex or VHF double-channel simplex may be used. The modulation system employed is known as FSK-AM, that is, amplitude modulation with frequency shift keying between two modulation tones, one providing mark and the other providing space digits. The overall bandwidth of the system is 40kc/s on VHF and 60kc/s on UHF.

The modulation system selected is not the ideal one, but it has the commanding merit of enabling standard aircraft transmitter/receivers to be used with little or no modification. The bit-rate of 750 is about the maximum which can be accommodated with this type of modulation as it covers the whole of the audio bandwidth of the aircraft transmitter/receiver.

Stromberg-Carlson Low-Speed System Another system currently being evaluated at the FAA experimental centre is the Stromberg-Carlson Automatic Binary Data Link, which is essentially a low-speed system of simplified design. A main feature of this equipment is that the narrow bandwidth required (about 200c/s) means that, with suitable filtering, speech and data can be transmitted simultaneously on the same frequency. The equipment plugs into the standard aircraft transmitter/receiver, and it is hoped that the cost of the airborne equipment will bring it within reach of the private aircraft owner.

Tacan Data Link An interesting development which apparently has not been adopted was the use of Tacan as a data transmission medium. This work was sponsored by the US Navy and was essentially a frequency division multiplexed system with no fewer than 126 separate channels in the 1,000Mc/s band. Tacan distance-measuring, combined with VOR to constitute Vortac, is of course the ICAO standard short-range navaid.

Digicall Another attempt to produce a simple data link suitable for small aircraft is the Motorola proposal called Digicall. The system provides for 19 discrete messages and 38 distinct altitudes with a display and insertion similar to that of AGACS, to which it is thought that it might be complementary.

Marconi LF Teleprinter Receiver A typical example of airborne equipment to perform the function of receiving advisory

Fig 4. Receiver, aerial and Creed teleprinter for the Marconi AD.308 HF system now being used by BOAC on the North Atlantic

information only is the Marconi teleprinter receiver AD.308 (Fig 4). This comprises a small transistorized receiver for LF frequencies between 90 and 150kc/s, operating in conjunction with a lightweight Creed teleprinter at a speed of some 50 bits/sec. The advantages of VLF for reliable long-range reception are clearly shown in this type of equipment. It has been in operational use by BOAC over the North Atlantic for about two years, mainly for the reception of meteorological broadcasts, and has proved most satisfactory.

Secondary Surveillance Radar The possibility of using the air-ground coded transmission of the civil secondary surveillance radar system as a data link for altitude telemetering is being considered. The reply which the airborne transponder of the system gives to an appropriate interrogation from a ground transmitter consists of a pair of framing pulses, 20.3 microsec apart, between which any combination of a group of information pulses can be transmitted. The number of pulse positions in current production equipment is six, giving a maximum coding capability of 64 codes: the possibility of extending the number of information pulses to twelve or thirteen is being discussed. Such an extension would increase the coding capability to 4,096 or 8,192 codes if any number of information pulses could be present, but it may be found better to use only codes containing, say, six information pulses—giving 924 or 1,716 codes.

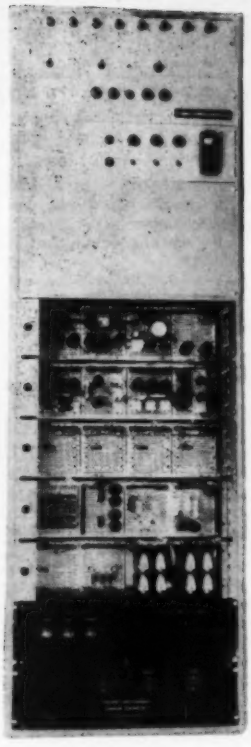
There is also a ground-air coding process, known as "moding," which permits different kinds of information to be elicited from the transponder by varying the interrogation mode. On one mode currently in use some of the 64 codes are being used for procedural purposes. Using a different mode, the Ministry of Aviation is about to embark on an experimental programme of height telemetering, using Cossor SSR.1251 transponders modified to accept the output of an altimeter through a GEC analogue-to-digital converter. With this facility, the secondary radar system, which basically measures range and bearing, can simultaneously measure all three positional co-ordinates of a suitably equipped aircraft. The greater the coding capability of the system, of course, the greater the precision of the transmitted information: in the USA the view is taken that more than 64 codes are necessary to achieve a "lamination" of controlled airspace sufficient for ATC purposes. But considerable additional equipment complexity must result from such an increase in coding capability and the merits of the case are debatable. It is interesting to note that a spokesman for FAA has recently advocated automatic secondary radar height reporting up to 100,000ft.

Decca HF Data Link For the purpose of repeating position information derived by Dectra from the aircraft to the ground, a data link has been developed by the Decca Navigator Co. The equipment is capable of transmitting from the aircraft to the ground Dectra tracking co-ordinate, ranging co-ordinate, altitude and identity, in response to a ground/air interrogation. In the ground equipment the information may be displayed in several ways including punched tape for data handling, a reconstructed aircraft Flight Log or a cathode-ray tube display.

Cossor Experimental HF Link Experimental equipment built by Cossor Radar & Electronics is shortly to be subjected to operational evaluation. It is essentially a test vehicle and is intended to provide an assessment of the reliability of digital data transfer systems under operational conditions and in the face of propagational difficulties. BOAC, who are particularly concerned with the North Atlantic problem, are co-operating by flying the test vehicle on the North Atlantic route; the ground equipment will be operated from the Ministry of Aviation establishment at Birdlip. The range requirement implies the use of HF for transmission and consequently a low bit rate of 50 per second is employed. The ground-to-air interrogations, which will occur at regular intervals, will embody identity characteristics which the airborne unit will recognize. Upon recognition, the airborne unit (Fig 5) will encode and transmit one of 11 prearranged binary encoded messages together with a synchronization pattern. In addition, facilities are available for the transmission of variable data, set in manually or automatically. In the ground equipment (Fig 6) the synchronization pattern is identified, accepted and used as a trigger for reception and decoding of the airborne message. The preset message is displayed in digital form and the manually set message is decoded and displayed in decimal fashion. The cycle time will be so arranged that the "dead" time between transmissions is at a minimum in order that the maximum number of messages may be passed in the allotted time. It will be of the order of two or three seconds. As the message content—in the case of the preset data—is known by prearrangement there is no need in the test vehicle for parity checks and other fail-safe devices; and a detailed examination of the received message by comparator techniques is possible. The binary sequence of the 11 available messages has been carefully chosen to ensure that the widest possible range of conditions is applied to the system.

Military Systems Two American systems which have been commercially developed primarily for military use are worthy of mention. They are the Hughes DIGIKEY and General Electric DISCOM. DIGIKEY has an interesting method of pilot-data insertion. A limited number of push-keys are covered by a moving chart with symbols over the key positions. When the pilot has pressed the appropriate symbol key the chart moves on to present a further set of symbols for sequential transmission. The ground equipment reconstitutes the messages.

Fig 6. Experimental ground unit of the Cossor HF data link (right)



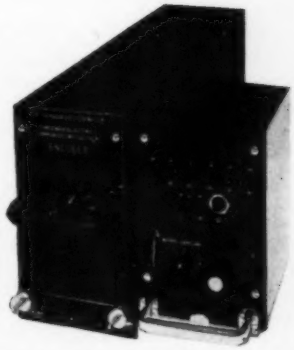


Fig 5. Airborne encoder and control panel for the Cossor data link

The DISCOM (Digital Selective Communications) provides 36 standard messages and 48 alpha-numeric characters for flexible message construction. Speed of the system is 50 bits/sec and it is claimed that its flexibility makes it attractive for civil use, even as a competitor to AGACS.

An interesting possibility which could appear at an earlier stage than a sophisticated system is automatic position reporting in three dimensions, thus removing the need for fixed reporting points. By means of suitable transducers attached to position-fixing navigation aids and to the aircraft altimeter it is quite reasonable to obtain fully automatic reports from aircraft without crew intervention and without extremely complex airborne equipment. In this connection there seems to be a good case for reporting position and height as deviation from flight plan. A moving graticule with its centre on the projected flight plan position might be a convenient way of reporting such deviation where the aircraft's actual position becomes a square reference number only. This type of reporting lends itself well to a Doppler navigation system incorporating a computer.

Another intriguing suggestion is of some importance to long-range data links on the HF bands. By back-scatter measurement techniques it is now possible to determine on which of the family of five aeromobile frequencies most reliable communication can be achieved at that time. It is thought that channel-selection in the aircraft might be controlled remotely, so that without crew intervention the optimum frequency is always in use.

It has been shown quite clearly that there is no shortage of electronic techniques for the design of data links, but there is unfortunately no agreed international requirement from which equipment designers can proceed. Even with the resources which FAA have brought to bear it has not yet been possible for them to agree on a firm system concept, although the findings of their evaluation trials are awaited with keen interest. It does seem likely that the complex automatic ATC system may well evolve before its associated communications link.

Experience has shown that the time taken to achieve international agreement on equipment standards is so long that it is highly desirable that a start should be made immediately to define at least the operational requirement. Even now it can be seen that many types of equipment representing several design approaches are emerging. The longer this goes on the more difficult international agreement is likely to be.

FLIGHT SYSTEM SURVEY...

One of Royston Instruments' CMM400 series flight recorders, the 400/7C for recording 270 parameters on six channels for eight hours. The tape cassette, in the right-hand unit, can be changed in seconds

Flight-recorder Prospects

THE basic function of a flight recorder is to register in the aircraft, and preserve, a running record of significant flight data so that, after an accident or incident, the record shall yield a history of events leading up to the critical moment. The desirability of such a device in transport aircraft has been officially recognized for twenty years, but any legislation has been consistently baulked by shortcomings in equipment, either at the design or the manufacturing stage. Yet even the few and relatively unsophisticated recorders which are now being carried on passenger services have already proved their worth beyond question. Recorders of the calibre now available can undoubtedly avoid a repetition of the aeronautical detective epics which have been necessary to pin down the causes of some mysterious disasters.

But that is not all a recorder can do. A whole new field, a new approach to maintenance and overhaul procedure, has been opened up. With comparatively simple, compact and cheap equipment it is now possible to run a continuous analysis of aircraft behaviour, component performance, serviceability and wear while still preserving the crash-recording facility. Prospects are dazzling, extending even into flight planning and traffic control; and there is a possibility that each individual aircraft could be calibrated by its recorder to allow flight-planning to much more precise limits than can at present be contemplated. Such prospects are based on original work done by Royston Instruments Ltd, who have over the past four years developed a range of specialized electronic tape recorders which offer the full flexibility in recording and analysis of tape systems. Lockheed Aircraft Services have acquired the production licence for America and are now manufacturing and marketing the MIDAS system, as it is called.

Recorders Made Mandatory Legislation requiring the carriage of flight recorders in passenger-carrying aircraft was first put into effect by the American CAB in 1957, after two abortive attempts in 1941 and 1947. The requirement was that, by July 1958, all air-carrier aircraft of over 12,500lb gross weight operating at over 25,000ft should carry a recorder for i.a.s., height, heading, vertical acceleration and elapsed time. The recorder should operate from the beginning of take-off to the end of the landing and the tape should be retained for 60 days after a flight. Various amendments and additions to this rule have since been made, including several delays to allow operators to survey the recorder market and take advantage of newer equipment and install it in an orderly and economical sequence. But by May this year there should be something like full coverage of aircraft flying at 25,000ft or above.

The Federal Aviation Agency's Technical Standard Order C51 states that recorders should cover the "basic five" parameters and should conform to one of three types. Type 1 may be mounted anywhere in the aircraft, but must survive a crash impact of 1,000g and 1,100°C flame over half the container for 30min. Type 2 need only survive flame for 15min, but must not be installed near wing spars or fuel tanks. Type 3 must be ejectable and therefore need not survive flame. Arinc, the industry's radio authority, wrote two "characteristics," 541 and 542, which broadly followed the FAA rules and types, but stipulated rack-mounted electronics and plug configurations. Arinc 542 covered recorders producing mechanically inscribed material and 541 stipulated magnetic tape and about 60 channels in addition to the "basic five." NASA meanwhile issued the VGH recorder specification which, as the initials imply, required speed, vertical acceleration and height recording. The VGH was mainly intended as a fatigue meter for B-47s and B-52s.

Three recorders, generally meeting FAA Type 1 and Arinc 542 specifications, were produced by Lockheed Aircraft Services, Waste King and General Mills (the last two are actually grain-milling concerns); and it is these which have been installed in jet transports. They generally inscribe continuous traces by indentation of broad metal type which itself has the heat-resistant properties. Minneapolis-Honeywell also proposed a complex flight recorder, primarily for TCA, but this project has been modified.

The "basic five" channels are limited, but even these have proved useful on several occasions, notably the recent DC-8 collision near New York when the recorder was recovered even though the DC-8 crashed into houses. The recorder was mounted near the forward passenger door in the main cabin and showed that the aircraft had remained substantially on course until just before the Preston holding point. This it passed 3,700ft higher than cleared and at some 358kt instead of the mandatory 180kt. The tape indicated, too, that the aircraft was eight miles beyond Preston when the pilot radioed that he was approaching it. Recorders have also helped in less drastic incidents. It was suspected, for instance, that a jet airliner leading-edge flap was shed because of excessive speed, but the tape denied this and a design fault was found and cured. Search for the recorder is now one of the most immediate accident investigation procedures.

If a record is ejected from the aircraft it must be provided with a means of flotation, a radio beacon and a dye marker. Some 72 per cent of the earth's surface is water.

The FAA is enthusiastic about recorders. It wants, eventually, to achieve "across the board" coverage with an increased number of channels recording engine and systems behaviour and more flight-path parameters. A project just completed is that of a special microphone to record crew conversation as well.

Royston MIDAS In Britain, progress towards legislation has been somewhat slower, although it was stated in Parliament last December that tenders were to be issued for development of crash recorders for MoA. RAE Farnborough, as well as Royston Instruments Ltd, has been working on such equipment. It was the Royston MIDAS project which first opened up the very wide horizons of the recorder as a maintenance tool.

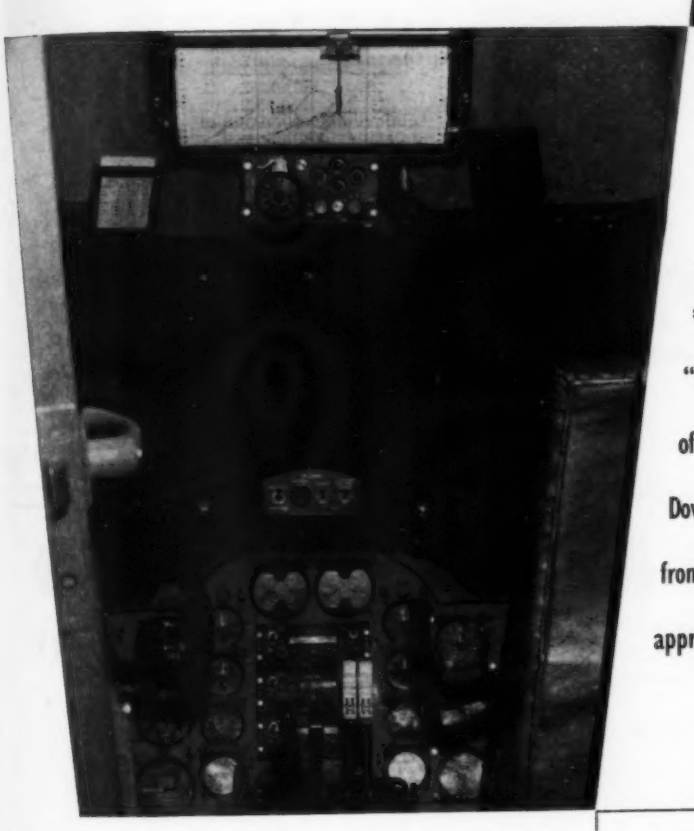
The latest CMM400 series of flight recorders cover seven channels on a 0.5in-wide tape moving at 0.1in/sec. Each of six channels is time-multiplexed to record from 45 inputs once every six seconds, making 270 channels in all. The seventh channel provides time data for controlling the de-multiplexer in the play-back equipment, for recording GMT and for aircraft identification, date and flight number. The recorders are produced in various forms corresponding to Arinc 541 and FAA type 1 or 3 survival characteristics. Standard tape play-back equipment can be used, together with relatively simple equipment from which a variety of types of direct and computed investigation can be completed. Various scales of play-back equipment can be distributed along an airline's routes to allow anything from "quick-look" checking to comprehensive statistical evaluation of the same tape record. There is no need to use the full potential of the tape immediately. The recorders can cover various durations up to 160hr and the tape cassettes can be changed by unskilled labour in a matter of seconds.

Royston have suggested that, for crash-recording purposes, it is the last hour of flying which really counts; and their ejectable unit might be a sub-station in the tail of the aircraft, recording on a continuous one-hour loop of tape. The ejected unit would be a good deal smaller than the main unit used for maintenance recording although it would still hold the full number of parameters. It has been demonstrated that the tape can survive at least six weeks' immersion in sea water without loss of information.

Royston analysed civil airliner accidents over the past five years and determined 36 factors which would have indicated all the causes. The 36 factors accordingly represent the necessary minimum to analyse virtually any subsequent accident. They include the "basic five" and also engine power, fuel, control surface, flap and airbrake angles and the angles of their related tabs, cabin pressure and outside air temperature, autopilot servo position, ILS localizer and glide-slope signals and pilot's instrument indications. An additional 121 parameters for maintenance include indications of all system control positions and such factors as actuating motor voltages. The voltage required to operate a flap motor, for instance, will indicate the mechanical resistance in the system, showing a need for lubrication, inspection or change of unit. Repeated test operations can be avoided and, Royston point out, 40 per cent of the operating cycles of a flap are done for test purposes and not in actual operation. Considerable wear could therefore be saved. In addition, maintenance recording provides a definite history of wear and operation, which could allow overhaul life to be less conservatively rated. A final possibility is tape recording of actual operation of a complex electronic system in flight to allow rectification without further testing on the ground.

MR. J. C. BAMFORD, Chairman and Managing Director of J. C. Bamford (Excavators) Ltd says:

"We fitted Decca because we operate into many small, ill-equipped airfields all over Europe and we must be able to fly in any weather day or night, with the same regularity as from any major airfield".



Cockpit of the de Havilland Dove 8 owned by J. C. Bamford (Excavators) Ltd., showing the Decca Flight Log and Decometers. The installation consists of a Decca Mark 8 Receiver (½ ATR) and Computor (½ ATR), Flight Log and Receiver control boxes and display head, the total weight of all units being less than 45 lbs.

THE DE HAVILLAND AIRCRAFT CO. LTD., suppliers of the DOVE 8 aircraft, state:

"Decca is a proven system for the operator of executive aircraft such as the de Havilland Dove 8 who must frequently navigate away from airways and use airfields where approach facilities are often non-existent".

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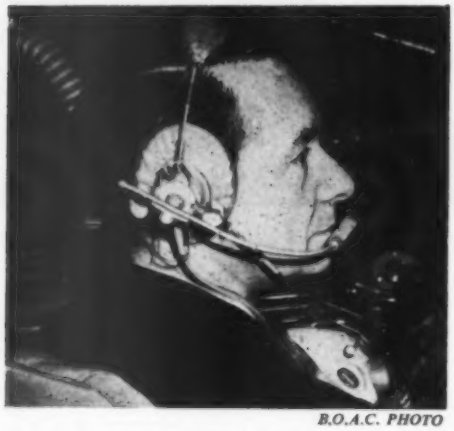

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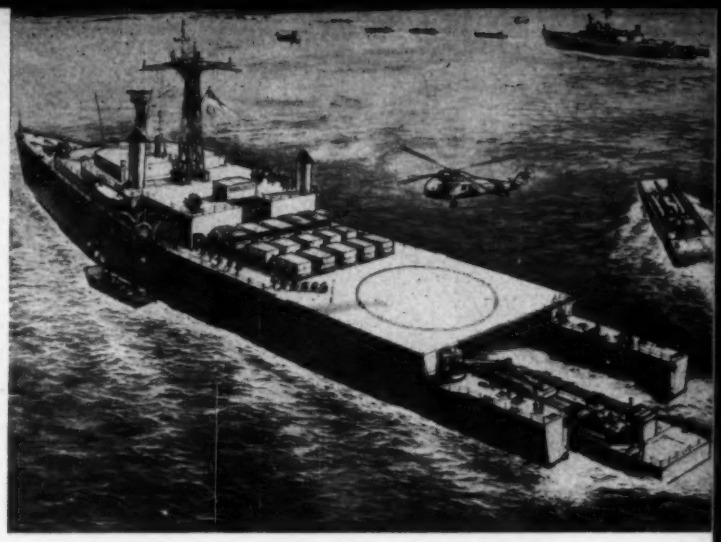


An artist's impression of the Royal Navy's new assault ship, building of which was announced in the First Lord's explanatory statement on the Navy Estimates for 1961/62 (see p. 229): the vessel has a helicopter platform and is designed to carry landing craft

Defending Central Europe

AN air defence exercise involving the the two tactical air forces controlled by Allied Air Forces Central Europe (AIRCENT) was held last week. It was designed to counter a large number of simulated aerial attacks directed against Central Europe from points close to the eastern boundary of the AIRCENT command; defensive forces were drawn from the intercepter squadrons and Nike Hercules surface-to-air missile units assigned to 2nd ATAF (RAF, Netherlands, German and Belgian Air Forces) and 4th ATAF (US, French, German, Canadian Air Forces), supplemented by fighter aircraft units of the French Air Defence Command (DAT). The exercise was one of a series run every four months to test and practise the air defences of the Central Europe region.

RAF Germany AOC

EARLY in April Air Cdre E. G. Jones, CB, CBE, DSO, DFC, is moving northeastwards from Fontainebleau in France to München-Gladbach in Germany: having been Assistant Chief of Staff (Intelligence) at AAFCE headquarters since June last year he is becoming AOC, RAF Germany (Second Tactical Air Force), from April 7. His previous appointments have been those of Commandant of the CRE at Brampton and command of RAF Wyton.

Air Cdre Jones, who will become an air vice-marshal in his new appointment, won both the DFC and DSO within six months in Greece in 1941 while commanding No 80 Sqn: he gained the DFC for leading a mixed

Air Cdre E. G. Jones

force of Hurricanes and Gladiators against enemy bombers and fighters over Albania (an engagement in which the RAF pilots destroyed 27 aircraft without loss); his DSO was won for patrols over the Greek front. Later in the war he served in Europe with No 83 Group, as group captain in charge of operations and subsequently in command of No 121 Wing (Typhoons).

UAS Future

AT the annual dinner of the University of London Air Squadron in London last Friday it was clear that the university air squadrons are having to fight harder than ever to survive.

In welcoming the guests the CO, Wg Cdr V. Rees, asked whether the country got value for money from the UAS. Both the present minister and his secretary of state were former UAS members, he said, but their membership had been an intangible benefit until now. Some 28 UAS members had attained air rank and two had become Cs-in-C. Ex-UAS pilots were now twice as likely to complete RAF pilot training as other entrants. Since the abolition of national service, the UAS were the only preview of the Service available and they influenced the best aircrew prospects. In view of the expected expansion in universities, the UAS should also be expanded.

Proposing the health of the squadron, the Secretary of State for Air, Mr Julian Amery, recalled that the UASs had originally been formed to make future leaders air-minded. People were now naturally air-minded. The heads of the Service were favourably disposed to the UAS, but the squadrons must produce concrete results in the form of regular aircrew if their retention was to be made easy for the planners. Aircrew applicants of a sufficiently high standard were hard to find, but Transport Command was to be increased three-fold and the deterrent would remain airborne. The demand would not decrease during the next ten years.

2nd ATAF Post

A STAFF change at 2nd Allied Tactical Air Force headquarters, Germany, has been announced: the post of Deputy Chief of Staff (Air) has been taken over by Air Cdre John H. Lapsley, OBE, DFC, AFC. He succeeds Air Cdre R. J. B. Burns, CBE, who from next Monday is to become Director of Flight Safety at Air Ministry.

Air Cdre Lapsley has previously been at 2nd TAF as Group Captain Operations, before taking up his most recent appointment as Deputy Director of Joint Plans at Air Ministry. He is an ex-apprentice, having gone to Cranwell on a cadetship; among his previous posts have been the command of No 74 Sqn and of RAF Wahn. His predecessor at 2nd ATAF, Air Cdre Burns, is a South African; prior to becoming Deputy Chief of Staff (Air) he commanded RAF Wildenrath in Germany.

IN BRIEF

The Duchess of Kent, who named the aircraft carrier *Centaur* in 1947, is to attend the ship's re-commissioning ceremony at Portsmouth on March 3.

What is described as "the biggest air pageant ever staged in Australia" is being held this weekend at Avalon, near Geelong in Victoria, organized by the Air Force Association.

The Potters Bar branch of the RAFA is celebrating the 21st anniversary of the inception of the D.H. Mosquito with a ball on midsummer eve (June 24) at Salisbury Hall, London Colney, where the first of these aircraft was built in secret and is now permanently housed.

Eight Books of Remembrance, bearing the names of over 105,000 men and women who gave their lives while serving in the RAF and its associated Services during the Second World War, are to be placed in the RAF Church of St Clement Danes on May 7.

Air Cdre A. G. Dudgeon, Commandant of the Air Training Corps and RAF section of the Combined Cadet Force, has been attending conferences in Paris and Montreal to work out arrangements for this year's international air cadet exchange scheme.

No 194 Sqn (India-Burma-Malaya) is holding its 11th reunion dinner on Saturday, April 15, at the Mapleton Restaurant, 39 Coventry Street, Piccadilly, London W1. Tickets (£1) from the hon secretary, Douglas Williams, 56 Mottingham Lane, Lee, London SE12 (Kip 1025).

The captain, co-pilot, navigator and signaller of a Britannia of No 99 Sqn—respectively Flt Lts D. West, G. Shipway and D. Hancock and F/Sgt L. Bennett—were yesterday being presented with awards by the Chilean Ambassador in recognition of the part they played in taking relief supplies to the earthquake-stricken areas of Chile last year. They have also been made honorary members of the Chilean Air Force.

Mr S. T. Gunnis, "helpmeet and guide to every holder of the office of Vice-Chief of Air Staff at the Air Ministry," receiving a presentation cigarette-box from Marshal of the RAF Sir William Dickson on retirement from the post of personal assistant to the VCAS. Mr Gunnis, 61, joined Air Ministry shortly after it was formed in February 1919 and became PA to the first VCAS, Air Marshal R. E. C. (later Air Chief Marshal Sir Richard) Peirse, when the post was created in 1940

Progress with the biggest aeroplane ever put into production in Britain is indicated in this picture taken at Weybridge. The nose section of the first of 45 Vickers VC10s for BOAC is seen shortly before being joined to the main fuselage

AIR COMMERCE

THE BRUSSELS TRAGEDY

THE Boeing 707's passenger fatality-free record since it began scheduled services more than 2,000 million passenger-miles ago was broken on February 15 in a tragedy involving one of Sabena's five 707-320s near Brussels Airport. All 61 passengers (who included the 17 members of the US world figure-skating team) and the flight and cabin crew of 11 lost their lives. One person on the ground, a farm worker, was killed.

According to M. Willem Deswarte, director-general of Sabena, the attempts to land "were watched through field-glasses from the control tower and it is clear that the aircraft presented itself normally at the approach to the runway. The Boeing then circled the airport three or four times in an abnormal position before gaining height and abruptly crashing."

The airport commandant, A. J. Debruyn, said: "The pilot made his approach towards runway number 20, running from north to south. He overshot it and then turned round again and re-entered the approach zone." M. Debruyn said he heard an explosion and saw smoke spiralling upwards. He said the aircraft control tower received no distress call from the aircraft.

The Belgian Government immediately ordered a full inquiry. The Sabena crew (all Belgians) were as follows: pilot, Capt Louis Lambrechts; co-pilot, Capt Jean Roy; navigator, J. M. Kint; radio operator, L. Eduwaere; stewards, P. Vandenbussche, R. Colette, M. de Mayer, H. Vernimmen; stewardesses, P. Trullemans, J. Rombaut.

GHANA AND BOAC

A CHEQUE for £160,000 was accepted from the Ghana Government by Sir Duncan Cumming on behalf of BOAC Associated Companies on February 15. This sum represents the 40 per cent BOAC shareholding in Ghana Airways which, as amicably agreed a year ago (*Flight*, January 22, 1960) it was Ghana's wish that BOAC should relinquish.

Sir Duncan said: "BOAC has been glad to assist in bringing Ghana Airways to the stage where the Ghana Government is able to assume full ownership and looks forward to continuing in the future the excellent relationship built up over recent years." At the same time he signed an agreement renewing the contract between the two airlines, dating back to July 1958, whereby BOAC provides management-assistance (12 BOAC staff are at present seconded to Ghana Airways), trains the future Ghanaian management—eventually 112 in all, in the UK, and operates a pool service on the Accra - London route.

The background to this not unexpected step was given in *Flight* for January 13 (page 65) and March 4, 1960 (page 322).

PRODUCT IMPROVEMENT BY FOKKER

ALL Fokker F.27 Friendship series 100s (Rolls-Royce Dart RDa.6 of 1,600 s.h.p.) are to have their all-up weight increased from 37,500lb to 39,000lb. Similarly, all F.27 series 200s, namely all Friendships powered by the 1,910 s.h.p. Dart RDa.7 528s, are to have an even greater increase—from 37,500lb to 42,000lb.

The result of these improvements is, of course, increased payload-range performance and lower operating cost. From the performance angle it is expected that series 100 Friendships which have Dart RDa.6s fitted with Nimonic 105 turbine blades (allowing max continuous JPT of 625°C) will be able to operate at 39,000lb up to ISA plus 16°C at sea level. Similarly, all Friendship 200s with RDa.7s having turbine blades of similar material will, it is expected, be certificated to take off at the new weight of 42,000lb in temperatures at sea level of up to ISA plus 25°C.

These weight increases apply also to the Freightship powered by RDa.6s (F.27 series 300), and to the Freightship with the RDa.7 engine (F.27 series 400).

FLY LATER

ANNOUNCED last week by BOAC and United Dominions Trust, the London finance house, was a "Save Now, Fly Later" scheme intended to "encourage winter travel to sunshine places." People participating are eligible to join a new club to be known as the BOAC Sunshine Club. The prospective traveller first completes an application form which he can get from BOAC or an approved travel agent, and this, together with an initial payment, is then sent to the United Dominions Trust. Subsequent payments are then made to the UDT or to banks.

DOMESTIC CUNARDERS?

LATEST edition of the *Civil Aviation Licensing Notices*, the document published each week by the Air Transport Licensing Board, records Cunard Eagle's application for a licence to operate from London Heathrow *or* London Gatwick on the UK domestic trunk routes to Edinburgh, Glasgow, Manchester and Birmingham. Eagle want to operate at a twice daily frequency in each direction on each route, though initially a lesser frequency is asked for. Types of aircraft specified are Viscounts, DC-6s and Britannias, and eventually Vanguards, D.H.121s and [*sic*] VC11s. Fares would be identical to those charged by BEA.

These applications are likely to stiffen the forthcoming contest between British United Airways and Cunard Eagle, both of which independents have now applied for a generally similar series of BEA international and domestic routes. It is noteworthy that Eagle's bid for European international routes (*Flight*, February 3, page 166) was followed up by a request to the Board for permission to use London Gatwick as an alternative to London Heathrow, Eagle's main base. The case which British United Airways will make for their base at London Gatwick to be regarded as a UK traffic-generating area in its own right (see page 258) is thus likely to be endorsed by Cunard Eagle.

Footnote: Cunard Eagle announced last week that scheduled Viscount services from Manchester to Hamburg, Frankfurt, Rotterdam, Copenhagen, Rimini, Pisa, Ostend and Bergen will start in April and May. Cunard Eagle recently increased its fleet of Viscounts to four by buying two V.755s from Cubana.

Third from left in this picture is Mr Samuel C. Dunlap, TWA's vice-president cargo sales and market development, who has been in London promoting the US airline's freight business. Seen with him, left to right, are Mr Sam Leib, TWA's interline and military cargo manager; Mr Howard Goodrich, UK sales director; and Mr Gustave Barnett, UK cargo sales manager

Here are the first pictures to be released by British United Airways of their two first-line turbine airliners in the final livery chosen by Britain's biggest independent. Top, one of BUA's four Britannia 300/310s; below, one of the eleven Viscount 700/800/810s (actually a series 810)

NO FOURTH SECTOR

THE protest by Comet pilots at BEA's summer schedules, which require them to fly four sectors per duty day, is the third which has been made to the corporation's management. The pilots protested last March at four-sector duties introduced with the summer schedules for 1960; they protested again when the winter schedules for 1960-61 were introduced with the same arrangements; and they are protesting now. On the previous two occasions, schedules were rearranged so that the need to operate four sectors disappeared, and only on the route to Oslo and Stockholm, where the work-load is light, did the pilots agree to operate two return trips a day on a trial basis.

The kernel of the dispute is disagreement about what is a reasonable work-load for jet pilots on European airways. An arbitration board which studied the matter last March apparently gave no firm ruling, but suggested that "as experience of such changes becomes available, we hope that the corporation and the pilots will jointly seek to resolve amicably ... an objective assessment of work-load."

"Amicable" is a poor description of the present situation. The pilots have asked for an independent enquiry on scheduling; it has not been forthcoming, and the dispute has been referred to the National Joint Council for Civil Air Transport.

FILLING THE CL-44

A NEW analytical technique, using the probabilities of expected payload and density distribution, has been evolved by Canadair to enable operators to forecast the average load factor that can be achieved by a CL-44 or other type of freighter on a particular route. This was described recently in a paper to the 1961 SAE International Congress and Exposition of Automotive Engineering by Joseph A. Morley, Canadair's vice-president of commercial sales in North America. He displayed graphs on which those below are based. It has been common practice to calculate the average cargo density which can be accommodated by dividing the maximum weight-limited payload (63,375lb for the CL-44) by the gross cargo hold volume (7,226 cu ft for the CL-44). But in practice the density required to achieve a 100 per cent load factor will be at least 40 per cent greater than the figure calculated in this way, which works out at 8.78lb/cu ft for the CL-44.

Densities calculated like this are of little use because they take no account of the volume taken up by pre-loaded containers and pallets, aisle space and other clearances, amounting to about 240 cu ft in the CL-44. Deducting the latter from the gross volume determines the usable volume, and stacking efficiencies for different types of loading must be taken into account to determine the net volume utilized; applying these percentage efficiency factors results in a further reduction of about 1,000 cu ft in the CL-44's case to give the net volume. The nature of cargo loading (i.e., pallet, bulk, containers or a combination of these methods) gives different net volumes and corresponding densities: a combination of pallet-loaded and bulk cargo would give an average cargo density of 12.4 lb/cu ft, compared with the 8.78 lb/cu ft calculated on the CL-44's gross volume. A series of curves can then be plotted for each value of cargo density showing average achieved load factor and payload against mean expected load-factor and payload; these enable load factors to be forecast and the effect on achieved load factor of a given increase in net usable volume to be read off.

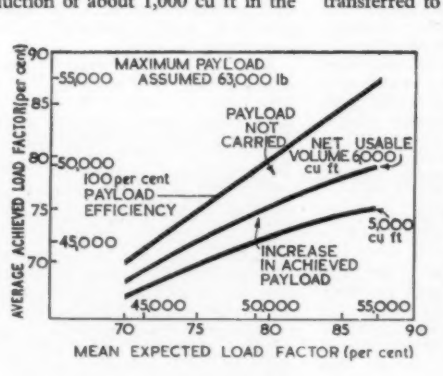
INDEPENDENT PILOTS' PAY

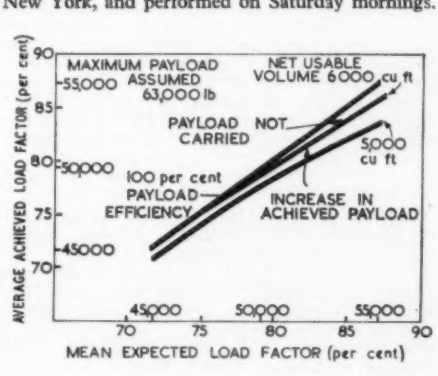
THE pilots' association, BALPA, has welcomed the independents' new route applications, but it points out (in as many words) that the independents should pay their pilots at least as well as corporation pilots are paid. "Neither the pilots themselves," says BALPA, "nor the corporations will benefit if the independents are allowed to cut their overhead costs by reducing their standards below the highest in the country."

NEW NORTH ATLANTIC OPERATOR

MAY 7 is the date that Pakistan International Airlines—subject to government approval—is to inaugurate a Boeing 707 service to New York. There will be one return flight a week out of London, operated by the single aircraft which PIA have been using on their Karachi - London services. It is not intended to lease or purchase a second 707; present timetables are to be rearranged to operate new and existing services with one aircraft. PIA intend to extend their route eastwards to Tokyo in 1963.

The PIA Boeing will leave London for New York on Friday evenings and New York for Karachi on Saturday evenings. Weekly servicing, undertaken now by PanAm at London, will be transferred to New York, and performed on Saturday mornings.





Left, load-density distribution at 10lb/cu ft, showing the influence of increased volume upon achieved load factor in an aircraft such as the CL-44. Right, for a cargo density of 13.5lb/cu ft the same increase in volume is seen to have a very small effect on achieved load factor (see "Filling the CL-44" on this page)

Just after sunset on Thursday, February 16, MEA's second Comet 4C, OD-ADQ, arrived at the airline's base at Beirut Airport, Lebanon. It was flown by Capt Hornall of MEA and by John Cunningham of de Havilland, who is assisting with crew training. Much praised is the grey and dark red interior, designed by 24-year-old Savine Khatib (right), a Lebanese interior designer

Middle East Melting-pot

THERE are bright hopes for the sale of more Comets in the Middle East. Sheikh Najib Alamuddin, chairman of Middle East Airlines, may exercise his option on a fifth aircraft for MEA. The option has repeatedly been extended and may be taken up "for use by a combination of MEA and another BOAC associate company." The purchase would presumably be made on similar terms to those now in force—two and a half per cent deposit, made by MEA, and the balance of payments over five years, guaranteed by BOAC.

Another potential customer is Iraqi Airways; Saudi Arabian Airlines is another. The latter operator has contracted its management to TWA, but this contract may be replaced perhaps by one secured by an Arab airline, possibly MEA or Misrair, both of which operate Comet 4Cs. Other airlines which might buy Comets are THY, in which BOAC holds six per cent, and Iranair.

BOAC-AC and MEA are now "in perfect agreement," Sheikh Alamuddin said in Beirut last week, and he added that "I would like to see as many Comets in the Middle East as possible. We hope to use those that we have for ten years."

His reason for wanting to see airlines in the Middle East standardize on Comets was the technical assistance and maintenance facilities that are now available throughout the area. BOAC and BEA spares pools were also a considerable potential asset to any prospective operator. The problem in the Middle East was one of low-density traffic; the Comet might be 10-12 per cent more expensive to operate per seat-mile than the Convair 880 or Boeing 720, but it was the right size and on cost per plane-mile it was cheaper.

No Iraqi decision about Comets can be expected until the airline leaves Iraqi Railways and becomes a separate company on April 1. Several re-equipment studies have been made in Iraq. Of two committees set up to decide upon a new aircraft, the first considered the Comet, Boeing 720, Convair 800 and Tu-104. But they were unable to reach a decision and decided to recommend a turboprop. This was said to have been done so that a choice could be made between the Vanguard, Electra and Il-18—the latter standing up much better among its competitors than did the Tu-104 to the British or US jets. KLM, who were called in as impartial advisers by the second committee, recommended Iraqi to buy Comets. Opinion in Beirut is that this airline only requires a period of stability to be able finally to make up its mind to place a Comet order, possibly for three aircraft.

The airline on which MEA's own plans for a fifth aircraft depend could be Kuwait Airways. Managed by BOAC since 1958, this airline is owned by Government and local interests in Kuwait, but a profit is guaranteed by BOAC Associated Companies. Kuwait has an affinity towards the Lebanon, and towards MEA, who may possibly take over from BOAC the management contract and operate a Comet on Kuwait Airways behalf. This would give MEA a useful toehold in oil-rich Libya, and valuable traffic rights on the service Beirut - Tripoli - London.

THE two news items under this common heading follow the visit of a staff member to Middle East Airlines in Beirut. Out of the present fluid situation may come more orders for Comets and eventually—if Arab dreams are fulfilled—a Pan-Arab airline.

NO Middle East airline question is so controversial as the Pan-Arab Airline proposal. As long ago as September 1959, Sheikh Najib said of Air Arab, as then it was called: "It is bound to come, and we shall be included." Much more recently Col Nasser Aljanbi, director of Iraqi Airways, is reported to have been urged by Gen Kassem, Iraq's prime minister, to "support any Arab proposal even if it may injure the interests of Iraq." An Arab airline study group is to meet in Baghdad on March 26.

Yet how strongly MEA—or any other Arab airline—believes that such an airline grouping could really be achieved is hard to gauge, since a Pan-Arab airline must depend upon a degree of political agreement and stability that the Middle East has not often achieved.

Admitting that political and economic difficulties lie in the way, MEA's chairman said in Beirut last week that "a Pan-Arab airline *is* going to be a reality." It was logical that common cultures should get together, and although Pan-Arab could not come about until these difficulties were settled, agreement was only a matter of time. At present, Arab states' bilateral agreements were negotiated individually; the Sheikh looked forward to a time when they were obtained on a bloc basis. He thought that pooling and technical agreements were the key to integration. MEA had a technical pool with UAA in Cairo, they were negotiating a pool with Iraq, and hoped to move closer to Kuwait Airways and Gulf Aviation. But MEA was also worried about some 22 Comet and two Viscount flights a week through Athens which, operated by the BEA consortium of BEA, Olympic and Cyprus Airways, fan out across the Middle East.

Although these arrangements have been agreed by the chairmen of the two corporations, MEA regard this as the sort of competition which should not occur in view of the association of Arab airlines with BOAC. "We cannot fight BEA," he said, "without affecting relations with BOAC also."

The problem facing BOAC, it seems, is to decide to what extent Associated Companies should attempt to hasten Pan-Arab by building-up MEA and by supporting other Middle East airlines. There is a risk either that the Arab airline idea would remain a dream, or that Pan-Arab would be led, in spite of BOAC-AC effort, by UAA, in which BOAC has no share. UAA now comprises Misrair and Syrian Airways; three DC-6Bs have recently been purchased to supplement its six Comets, and new routes are to be announced.

Sheikh Alamuddin believes that a unified Arab airline would have to join a major airline group to obtain reciprocal benefits, and that there is nothing to stop a close association between the corporation and an Arab airline. "Our sincere wish," he said, "is that we develop into Pan-Arab with BOAC."

MILWARD ON AMERICA

AT London Airport last Saturday Mr Anthony Milward, chief executive of BEA, talked to the Press on his return from a three-week visit to the United States.

The amount of money the Americans were spending on their airports was, he said, "absolutely fabulous." They were building enormous new car parks; this was a major source of revenue—he thought about one third—and it was the way the Americans made their airports pay. He confirmed that BEA would like their own terminal at London Airport Central. It would cost at least £1 million, and it would be on the north-east face. The Ministry had agreed that the building was necessary (a new passenger terminal in this location had been recommended by the Millbourn committee in 1957) and he thought that it would increase the airport's terminal capacity to the point at which this would roughly match runway capacity. He preferred the finger-and-gate system: though he had not seen Washington, "I don't like the mobile lounge idea very much because you can't trickle-load the aircraft."

He had been to Boeing to see the 727, and "they came out with

At a meeting in London last week, senior executives of BOAC, BEA and the British Transport Commission were given details of French and German monorail systems. This is the German Alweg monorail of the type which is to be installed between Haneda Airport and the centre of Tokyo. In a comment afterwards Lord Douglas said that he was "not sure that it was the system for London"; a railway link line might not be so fast, but neither would it be so expensive

all their plans." Compared with the Trident, it was "much more different than I thought, mainly much bigger." It was also more expensive—about £1½ million compared with £1 million. It had very good short runway performance; landing distance was probably a little less than that of the Trident. Yes, Boeing had "picked his brains" too, mostly on the matter of size, range and frequency. "What I like about the Trident are its size and range, which are just right for us." Two American airlines were interested in the 121, one big one and one smaller one. BEA might give up a place on the Trident line, but it depended on circumstances. At the moment the question did not arise, as an export customer could get spring '64 delivery anyway.

Mr Milward said that the US domestic airlines were experiencing a serious recession—"they are not expanding, and I got the impression that Capital will not be the only airline to disappear during the next twelve months. The position is serious for them, with all the new jet capacity coming along. There are jets everywhere. I have never seen such competition. On some routes there are half a dozen airlines. We have enough competition, heaven knows, but it seems crazy to me to have such competition. Some people say that if you have a pool that is the end of competition. It certainly is not so." American operators had shown a lot of interest in BEA's promotional fare structure, the like of which did not exist in the States, and which he believed was one of the secrets of BEA's profitability.

No, he had not seen the Vertol 107 or the Sikorsky S-61. The Ministry wanted BEA to buy the Westland 192C, which was more expensive to operate. BEA's plans for a Lands End - Scillies service were now out because of the safety aspects at the present stage of the sea crossing. BEA would like financial assistance for a Heathrow - Gatwick inter-airport helicopter service, perhaps at a frequency of six return flights a day in the summer. The need for such a service would increase as more fixed-wing operations transferred to Gatwick. Mr Milward referred also to a city-airport monorail (see picture above), to which BEA might contribute £1 million.

SILVER CITY'S RAILWAY LINE

THE price paid last week by Silver City for a major expansion of business is the operation by Compagnie Air Transport of three Super Freighters in their own right on the vehicle ferry services from Le Touquet and Calais to Lydd, and from Cherbourg to Hurn. In return, French Railways, major shareholders in CAT, have agreed to build a two-mile railway spur into Le Touquet Airport. This, in effect, will integrate the Silver City network—which is to be extended to Blackpool, Liverpool, Manchester, Leeds/Bradford, Birmingham, Newcastle, Edinburgh and Glasgow—with not only the French but also the European railway system.

The significance of Silver City's two miles of railway line is that passenger services will assume a much greater proportion of the airline's sales effort; if sufficient travellers can be attracted to the Le Touquet railhead, new equipment for car ferries can be postponed until the airline is in a sufficiently profitable position to justify the outlay of capital to P & O—a shipping company which has seen a poor return on the Hermes so expensively bought in 1958.

Last week the airline's chairman, Mr Eoin C. Mekie, could not say when the rail spur would be completed; he was releasing the news now because already travel agents were planning for the 1962 summer season. The full effect would not be apparent until next year. He did not expect to run car ferry services from the northern cities this year as "all our aircraft will be fully committed on the shorter-range routes." He did not know the cost of the spur, but it was "very substantial." On the subject of new aircraft Mr Mekie would not be drawn, though it had always been his ambition to use aircraft "built by a consortium of British and French companies." It seems reasonable to speculate that, if Silver City want increased capacity quickly, a suitable aircraft might be the Breguet 763.

So far as Silver City's current season is concerned, bookings are, in the words of the chairman, "extremely high."

The need for new equipment is not yet, it seems, pressing Silver City too hard, and it is not likely that we shall be hearing of a major order for a new type of aircraft for some time.

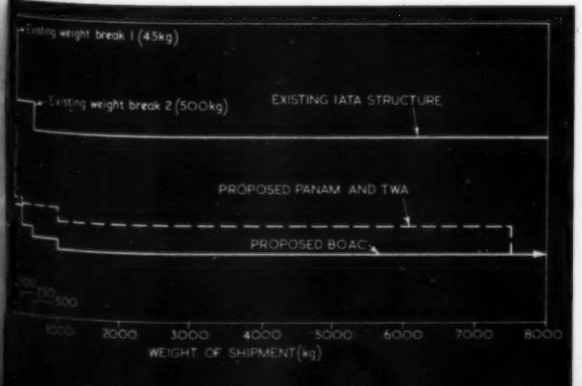
The new alliance will do little to increase utilization of the Bristol fleet, as the 170s are to be confined to the sea crossings from Lydd, Manston or Hurn. But another effect which it may have is to squeeze Channel Air Bridge out of interior France, and off the deeper-penetration routes to Lyons and Strasbourg. Unless some agreement can be reached with the French Government (or French Railways, who are likely to be main opponents of the "deeper penetration" proposals), or new services can be opened up elsewhere, Silver City may have temporarily blocked their rivals' next proposals for re-equipment and expansion.

BOAC's BARGAIN BASEMENT

SINCE last week's review of the news that the IATA cargo tariffs conference in Paris had broken down, the leading contestants have put some cards on the table. The accompanying graph shows the existing London - New York fare structure, with the two "weight breaks" at 45kg and 500kg, together with the proposals for reduced rates put forward by Pan American, TWA and BOAC.

The British corporation appears to have decided on cuts which, as was said after the conference by Mr Gilbert Lee, commercial director, would indeed "produce a lower overall rate than any other recommended." The corporation is proposing to introduce, and *will* introduce on April 10 if no agreement is reached, three new weight breaks. The upper one, at 1,000kg, cuts the rate to that proposed by Pan American and TWA at 7,500kg. For the moment BOAC is not disclosing its hand insofar as changes to the existing 45kg and 100kg weight breaks are concerned; but informed reports suggest that, in common with other European carriers, BOAC want to leave charges for shipments of these weights at their present levels. It will be seen that Pan American and TWA are proposing reductions at these lower weights, and it remains to be seen whether BOAC, and other European carriers such as KLM, will also cut rates at these lower weights if war breaks out.

London - New York cargo rates, present and proposed



But the fundamental aspect of the BOAC proposal is the big reductions recommended for the heavier shipments. This is a reflection of the need to fill the vastly increased freight capacity now being scheduled by the corporation both on its all-freight DC-7F services and on its 707 passenger services. The proposal to slash rates for shipments of 1,000kg and over from the present 13s to less than 5s promises the realisation of the freight "breakthrough" that the airlines have so long been talking about.

Obviously, the proposed BOAC across-the-board reductions will inevitably undermine many of the special commodity rates on which the transatlantic freight business has been largely built, and which BOAC, KLM and the other European carriers—unlike the American operators—do not yet want to discard. BOAC, in fact, say that they are considering "even lower rates for selected commodities to encourage greater use of air transport in specialized export trades." So that, as well as offering the lowest across-the-board rates, the British corporation will also be offering some of the best special-commodity bargains.

This artist's impression shows how one of two ex-Alitalia DC-6Bs will look in the colours of Societa Aerea Mediterranea, a non-IATA Italian air charter company affiliated to Alitalia which will be used for charter work, including about 350 inclusive tours between the UK and Italy this coming season. Represented in this country on Air Baltic by M. K. Kendall Ltd, the aircraft are available from May 20

AIR COMMERCE . . .

EUROPE'S RECORD YEAR

IN a year when world air traffic is provisionally estimated to have been one-sixth greater than that of the previous year, intra-European international traffic has shot up by a fifth. When it is remembered that Europe saw no substantial fare-reductions last year, and no remarkable improvements in national income, this rate of growth is striking evidence of the popular acceptance of air transport.

Recently published Air Research Bureau statistics reveal that 11 reporting members showed an average increase of 19 per cent. But the actual average for all European operators must be rather higher than this; Olympic Airways are believed to have almost doubled their European traffic last year, while TAP's international traffic in 1960 might well be more than double the previous year's level.

BEA and Air France continue to occupy the dominant positions in intra-European civil aviation. In fact, their positions are even more dominant than is suggested by the ARB statistics, for both airlines carry a substantial volume of domestic traffic which is excluded from the ARB's calculations.

A noticeable feature of traffic development last year was that the fastest growth was enjoyed by the smaller intra-European operators. Thus the five leading carriers—BEA, Air France, SAS, Swissair and KLM—each showed a below-average rate of expansion (these five companies account together for about three-quarters of total intra-European air traffic). With the exception of Sabena and Iberia, all the other smaller carriers experienced boom conditions, growth-rate ranging from Aer Lingus's 24 per cent to Finnair's 52 per cent.

Particularly significant was the rapid expansion of Alitalia's intra-European services; by the present time it is likely that the Italian carrier has overtaken KLM and moved into fifth place in the European league.

Carrier*	1960 passenger-kilometres 1,000,000†	Percentage increase	Percentage load factor	
			1959	1960
Aer Lingus	254	24	67	70
Air France	955	17	66	63
Alitalia	423	33	54	55
BEA	1,551	17	67	66
Lufthansa	386	25	52	54
Finnair	127	52	47	47
Iberia	118	16	54	61
KLM	508	16	46	46
Sabena	294	14	42	40
SAS	761	17	53	54
Swissair	568	15	59	58
Totals	5,945	19	58	57

*Olympic and TAP not included. †International traffic only; domestic traffic, which is significant in the case of BEA and Air France, is not included.

Alas, there is little evidence to suggest that increased traffic has meant improved finances. Total capacity increased more rapidly than traffic, and as a result overall load factor fell from 58 to 57 per cent. A study of individual load factors suggests that the two short-haul specialists, BEA and Aer Lingus, were the only carriers to make a profit on their intra-European operations. (To these two might be added TAP, which might well have made enough profit on its London service to have more than covered the losses on the Paris service.) The low load factors shown by such primarily long-haul carriers as KLM and Sabena suggest that their intra-European networks are still considered primarily as feeder services. It is a sobering thought that as long as such policies persist there is little possibility of putting European air transport on to a healthy economic footing.

BREVITIES

Today, February 24, Boeing expects to obtain FAA certification of the 707-120B and 720B (P &W JT3D-1 turbofans of 17,000lb).

Convair 990s will be introduced by SAS and Swissair on September 20, replacing SAS DC-7Cs and Swissair DC-6Bs on Far East schedules. These aircraft will be introduced on the South American route also.

Airframe overhaul cycle for the CL-44, to be introduced this summer by Flying Tiger, Seaboard & Western and Slick, has been set by the FAA at an initial figure of 13,500hr.

The official CAB investigation into the Eastern Air Lines Electra accident at Boston last October has found that the accident was, as widely speculated, caused by collision with birds.

A ten-page booklet, "Bird Hazard to Aircraft," is being distributed by the FAA to 5,000 airport managers and owners, and it is available to airlines and others interested in "halting the increasing peril caused to aviation by various types of airborne wild life."

Air-India will test its 707 Conway engines on a test plant soon to be installed at Santa Cruz Airport. It was designed by Heenan & Froude Ltd of Worcester, and has inlet and exhaust suppressors by Cullum Detuners Ltd.

The non-IATA carrier Trans Atlantica Argentina is reported to be negotiating the lease of two 707-220s from Braniff. At present the airline operates a twice-weekly L.1649A (leased from TWA) from Buenos Aires to Geneva via Rio, Recife and Lisbon.

On March 12 American Airlines will introduce what it calls "Stage 2 of the Jet Age," when it will introduce new turbofan "Astrojets" into service. The airline has 24 707-120Bs and 25 720Bs on order, either as new production aircraft or retrospectively modified.

The Italians have issued a Notam warning aircrews proposing to use Fiumicino NDB (call sign NF, frequency 273kc/s) of the existence of Prague broadcasting station (call sign CPHG) which operates on 272kc/s. [One of the matters being considered by the BOAC team investigating the recent Comet 4 incident near Fiumicino was the question of radio interference.]

It is reported that Douglas have decided to build up to ten DC-8s over and above the existing orders for 159.

BOAC is to operate Boeing 707s into Lima on April 11. There will be a twice weekly service from London, via New York and Nassau.

Just published by Ian Allan in the ABC Series is a revised edition of J. W. R. Taylor's book *Civil Aircraft Markings*. Priced 2s 6d, it is extensively illustrated and includes a list of all aircraft on the British Register and foreign aircraft likely to be seen at UK airports.

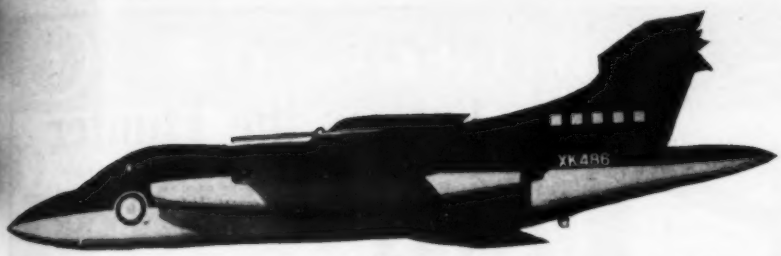
Mr William P. Lear is to give an annual award—a 36in-high silver trophy, to be presented first in 1962—"to the person . . . or organization in the US or other countries making the most lasting contributions to air-traffic safety." The announcement was made at a luncheon to celebrate the 30th anniversary of Lear Inc.

Mr M. M. V. Custance, Deputy Secretary at the Ministry of Aviation, has been made a member of the board of the Institut du Transport Aerien. At the same time Mr Henrik Winberg, Director General of the Swedish Royal Board of Civil Aviation, has been appointed a member of the ITA board.

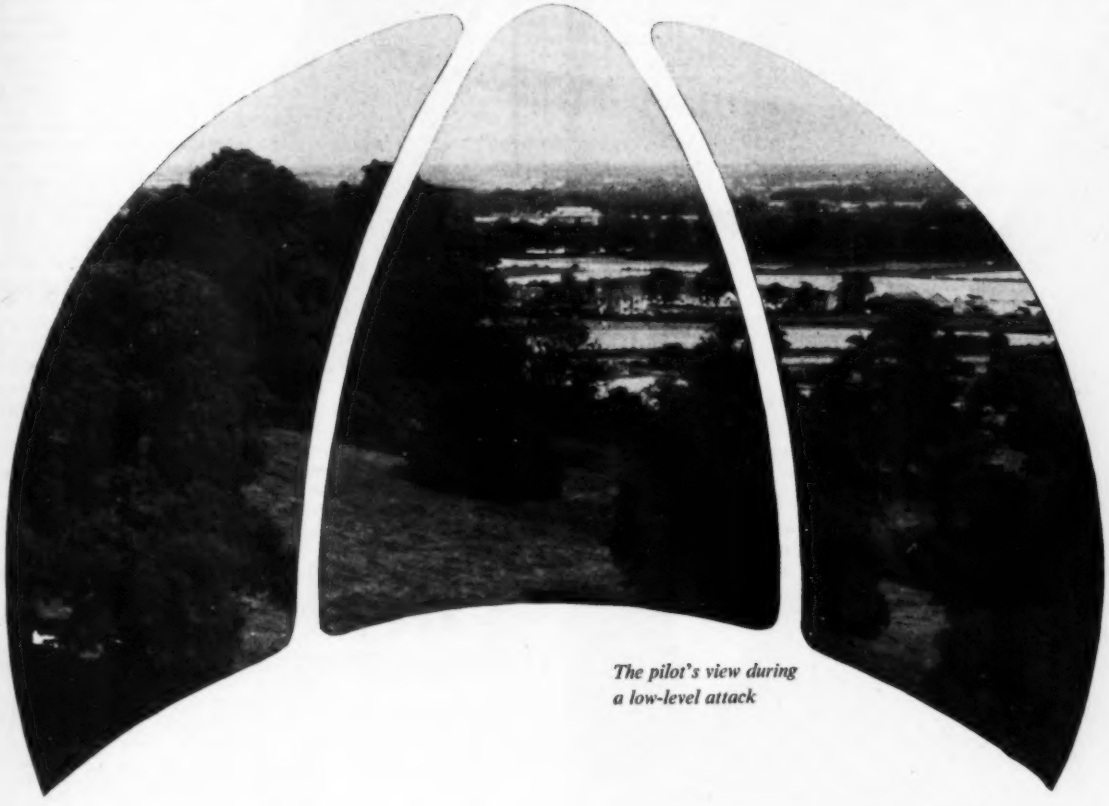
The Sixth Annual Air Transport Course sponsored by the Royal Aeronautical Society will take place at Oriel College, Oxford, from March 24-April 15. Lecturers, as in previous years, will be S. F. Wheatcroft, economics; K. G. Wilkinson and D. C. Tennant, operations; and A. R. Barrowclough, air law.

Alitalia has installed an IBM 7070 data processing system at its head office in Rome. Applications include accounting, stock control, payroll, passenger and freight revenues, traffic statistics, and aircraft utilization statistics, and being studied is the computer's application to production planning, tariff calculation, crew and aircraft utilization, and long range economic planning.

TCA are now using at Toronto the Edgehill Autostair mobile passenger stairway, which is mounted on a Karrier Bantam chassis. The unit is seen in action here with a new refinement—a retractable canopy usable as a snow-roof, umbrella or sunshade



Buccaneer navigation



The pilot's view during a low-level attack

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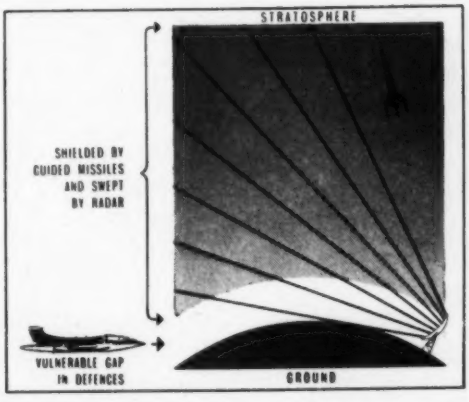

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Straight and Level

DID you see the report that the Welsh independent airline Cambrian Airways made a profit last year of some £50,000? And that the profit in the previous year was £40,000?

I wonder whether the thought that occurred to me on seeing these figures also occurred to you. Not just the thought that it is good to see Cambrian profitable—obviously it is good, especially as the airline was practically on its knees two years ago and would, but for Wg Cdr L. B. Elwin's refusal to be beaten, have gone out of business.

No—it is something more than that. This is the first time, so far as I am able to ascertain, that any UK independent has ever published its financial results.

● Last Tuesday Lord Boothby was to ask in the House of Lords "whether the Minister of Aviation still contemplates raising the landing fees at London Airport on April 1 to a point which will make it not only the worst, but by far the most expensive, international airport in the world."

I welcome Lord Boothby's sudden political interest in aviation, and would like to make two small comments:—

ONE: What does Lord Boothby mean by the "worst international airport in the world"? This is a pretty strong statement to make at any time, and particularly strong only a few days after IATA—in *their* attack on the Minister in the context of landing fees—described London's air traffic control facilities and approach and landing aids as "among the best in the world."

TWO: *Everyone* says that the new UK fees will be the highest in the world. I am sorry, but it just isn't so. If you land a Boeing 707 at Khartoum you will find that the landing fee is £266 10s, compared with the proposed £241 6s at London.

And the landing fee is only one of several charges exacted at other airports. In Iceland, for instance, a fuel tax is imposed that can run up a bill of more than £300 over and above the £8 landing fee for a 707. And in the Philippines you may have to sign a cheque for a "terminal fee," a "fuel delivery" charge *and* fuel tax amounting again to more than £300 over and above the £18 landing fee for a 707.

Had Lord Boothby been aware of these facts he would, I am sure, have worded his question differently. Or perhaps not asked it at all.

● "There we were, at 200ft over the sea, in our helicopter on an anti-submarine exercise from Eglinton: Lts Simpkin and Fyleman and Ldg Seaman Barker. Gradually the engine started to lose power, so we ditched. We jumped out into the water, inflated our Mae Wests. Up popped the submarine *Amphion*, who had been watching our descent on her periscope. Down came dinghies from the helicopter which had been operating with us. Along came the frigate *Torquay*, which had been taking part in the exercise, and picked us up. At the entrance to Lough Foyle we were put aboard a Naval launch, which landed us at Londonderry. Next day we were back on duty."—*news agency.*

All very neat and tidy—except for litter on the seabed. All right, lads, get fell in the volunteers for a spot of helicopter salvage.

● GENTLEMAN *with sound aviation knowledge and keen commercial brain would consider forming an air transport company with modern 'planes. Would like to contact group or individuals wishing to participate. Minimum investment £20,000. Advertiser will put in £120,000. Reply in confidence to Box R.932.*—From the personal columns of *The Sunday Times*, February 12.

● It is comforting to know that even Soviet Air Force pilots have their shortcomings, drawing down upon them the strictures of *Red Star* for lack of self-confidence and "misuse of alcohol." Perhaps a few exchange postings with the RAF and USAF would help to put matters right. A crew-cut, free issue of baseball caps, some rowdy guest-nights and a 24-hour sortie in a Shackleton would be good for the comrades' morale.

Splash, splingie, sploogie! H-E-E-E-E-L-P! Bubble bubble gurgle. Where's Jack? Where is our happy little boy inventor, eh? I would like a word with him. Electric flying machine indeed. Bubble bubble back-to-the-drawing-board gurgle

Senior engineer of Douglas Aircraft: "So this is your Mk 2 Vulcan you want us to hang Skybolt missiles on. Whereabouts do you want them?"
RAF crewman: "About here, but for heaven's sake be quick before the Minister changes his mind."

But they will have to go easy on the mild-and-bitter; and no flying their Migs through the London Control Zone without 24 hours' written notice to the Ministry of Aviation.

● "US Air Force is seeking this month to broaden the base of understanding for its modern aerospace counterforce capability. The program begins on the home front with an explanation of the counterforce posture the number one subject for Commander's Call along the entire Air Force circuit . . ."—from the USAF paper *Astro News*.

How's your reading capability posture right now? It's okay, is it? Good, well then, tell me what the heck that means, in English.

● Eastern Air Lines, so I read, reported finding a vacuum cleaner in the fuel tank of one of their Electras. They also collected 20 screws, a riveting tool and part of a paper cup from the fuel tank of another. Lockheed, the manufacturer, was fined £2,000 by the FAA.

This sort of thing happens in the best quality-controlled factories. I remember a foreign operator of a certain new British aircraft, after receiving repeated passenger complaints about funny-tasting drinking water, opened the tank and found inside, in an advanced stage of decomposition, a leather mallet. This was duly placed in a glass showcase in the airline's flight hangar alongside all the other objects supplied by the same manufacturer—including a tin mug, a bike pump, a pair of green socks and a cream bun.

● "The only lead we have around here is lead-time."

ROGER BACON

Sport and Business

PARTNERSHIP OF THE SKIES

FREE low-level airspace for the British private pilot is a concept which now seems to be as far away as ever. The Royal Aero Club's proposals, sponsored by Mr Peter Masefield as chairman of the aviation committee, are for freedom from control below 1,500ft except in the immediate vicinity of large airports. These proposals have been used as a starting point for discussion, but it seems doubtful if those whose responsibility is the regulation of air traffic have ever seriously considered that they might be adopted *in toto*, and then modified to suit the needs of commercial aviation.

Putting general aviation *first* and then arriving at compromise proposals suitable for both private and commercial users is, for Britain, an astonishing suggestion. Yet something akin to this approach has been adopted in the United States and a similar course has been taken by the French in relation to the new shape of the Paris control zone.

Here in Britain the off-airways pilot is faced, from March 1, with added restriction in the shape of a fully IFR London Control Zone and airways network. There can be no valid objection to full control if this is needed to ensure air safety. "See and be seen" is not a satisfactory philosophy when light aeroplanes and jet transports mingle in the same airspace. But private pilots are disappointed, to say the least, that some airspace at lower levels has not been left free for them, as it is in the United States and in France.

From last Tuesday, February 21, the US Federal Aviation Agency started to implement a proposal to raise to 1,200ft above ground level the minimum height of all controlled airspace except control zones. The latter, which extend upwards from ground level, will be restricted to a *radius of five statute miles* from controlled airports—although extensions may be made "to encompass the flight-paths of instrument approach and departure operations." The size of individual airport zone extensions will be determined by aircraft climb criteria developed specifically for the job, and each airport will be considered on a case-by-case basis.

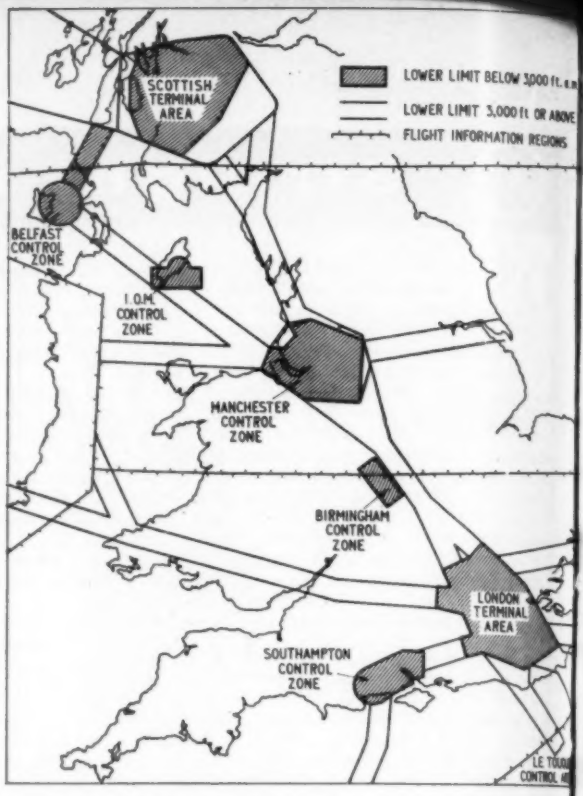
For IFR flights transition areas between control zones and airways will have a minimum above-surface level of at least 1,200ft, the only exception being in the vicinity of uncontrolled airports which have an instrument approach system, where transition floor-level drops to 700ft. This non-VFR airspace will be of limited width. Transition areas will be pierced by VFR corridors "as required and as possible."

All this means that, except when flying in the vicinity of controlled airports and of some uncontrolled ones where special instrument procedures apply, a private pilot in America has only to maintain 1,200ft or less to *know* that he is clear of controlled airspace—and he can legally fly, if he wants to, in the low VFR contact visibility limits "clear of cloud and in sight of ground or water."

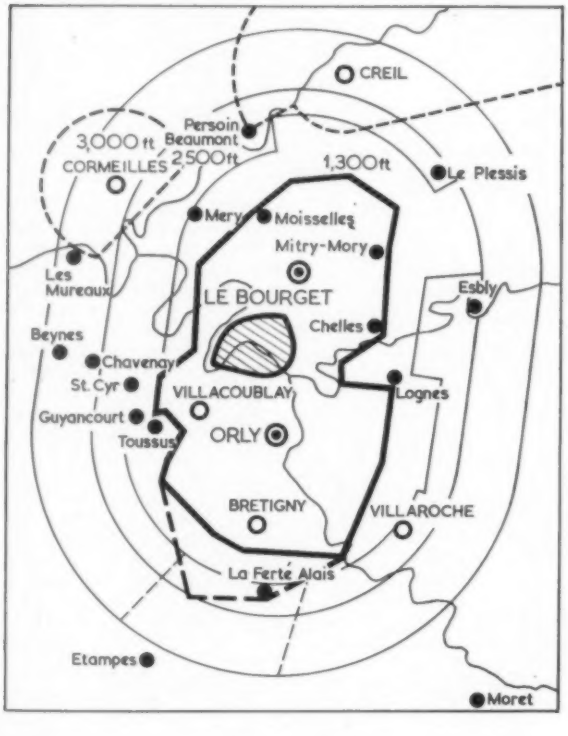
Complete revision of all the airspace in the United States will naturally take some time, especially as the structure is to be amended piecemeal. But the important decision—the policy-making one—has already been taken, and became effective last Tuesday.

In Great Britain the Royal Aero Club soldiers on, pressing for similar freedom of the air below 1,500ft except in the vicinity of large airports. To be fair, under-airways ceilings in the UK are already less restrictive than those in the USA—minimum airways height over the whole of the British Isles is 3,000ft. But the airway corridors are not the whole picture—there exist large areas of controlled airspace with a much lower floor. The London Terminal Control Area is an example. It has a "stepped" floor, in places not higher than 1,500ft, and it covers the greater part of South-East England. Since this minimum is height above sea level, and the highest ground in the area is nearly 1,000ft in places, the slice of airspace to which VFR-contact pilots are restricted when visibility is less than five miles is barely 500ft thick.

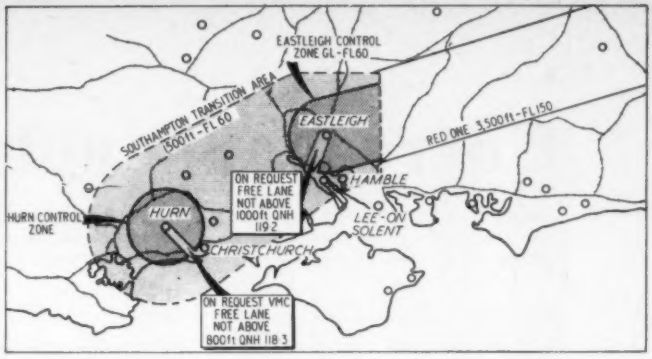
There is also the thorny problem of the size of control zones. To the general satisfaction of the private pilot—and apparently without much hindrance to the IFR operator—the London Zone was last year realigned and reduced in size. But it is still 32 statute miles across at its widest point, the Gatwick Zone is 27 miles long (nearly 14 miles each way on the extended centre line of the runway) and the Southampton Zone, covering Hurn and Eastleigh, extends from north-east to south-west no less than 44 miles. All



Division of Britain's airspace. Shaded sections are terminal control areas, which in instrument weather become controlled airspace. Airways are all controlled airspace, but have a minimum level of 3,000ft. London and Manchester Control Zones are permanently subject to instrument-flight rules



Controlled airspace around Paris has been experimentally arranged as shown in this diagram. Only the area outlined in heavy black extends upwards from ground level; the remainder of the controlled space has a floor which steps up from 1,300ft to 3,000ft. Below this the air is actually reserved for light aircraft only, and transports on IFR flight-plans are not allowed to enter



This hypothetical re-arrangement of the Southampton Control Zone shows how many square miles of airspace might be liberated for use by private pilots. The control and transition zones are controlled space in all weathers, but there is free space underneath the transition zone; free lanes through the control zone are indicated on the aeronautical chart. Information given includes maximum height of the lane, and the frequency on which the airfield approach is called to obtain entry clearance. Both free lanes follow line features on the ground

this airspace extends upwards from ground level and in IMC is out-of-bounds to all but fully equipped operators. The big London and Manchester Control Zones and all airways are IFR-only all the time, and special clearance must be obtained before light aircraft can enter or cross them.

Radical redesign by the FAA of US airspace poses questions as to whether we are making the best use of our own: whether we should cease to think in terms of VFR and IFR conflicts and embark upon a fairer apportionment of the air above us in terms of an equable partnership. The present system of free lanes to aerodromes in control zones is far from satisfactory; too much reliance is placed upon accurate track-keeping by scanty visual reference.

The free lane through the London Control Zone into Fair Oaks is a case in point. Before the zone was extended southwards a few miles in the tidying-up process, track guidance from the south was provided by the railway line from Guildford to Woking, whence it was about one minute's flying *on the same track* to the centre of the airfield. To keep Fair Oaks traffic clear of Wisley traffic, the free lane was then swept westwards to a terminal point at a cemetery that is not, of course, shown on the half-million map. There is no line feature to follow between cemetery and aerodrome and no radio or D/F with which position can be checked. Flying has been made more, rather than less, difficult—and, it might be argued, not quite so safe.

Another unsatisfactory feature of free-lane entry into control zones is that flight planning is complicated by lack of ready information. Free lanes are not shown on any map, and a long-distance telephone call is usually necessary to check the position of the lane.

If it were a simple matter to reduce the size of control zones, many of these free-lane problems would disappear. The design case is apparently that of a fully loaded Constellation or DC-6B climbing out through the zone with a 30kt tailwind on a hot day. Rate-of-climb may then, apparently, be only 200ft/min, so that for the aircraft to reach 1,500ft before it leaves the zone the latter must have a diameter of at least 24 miles. Add another 500ft for separation and some for luck, and the size of the zone assumes giant proportions.

It would not, of course, be practical to specify a control zone with a shelving floor, but it may very well be worth while having control *over two levels*; one, the small control zone proper, and the other the "transition zone" principle adopted by the FAA and the French Ministry of Transport. More private pilots would agree that the extra complication of maps and charts would be worthwhile if it gave free entry at low level to aerodromes now within the confines of control zones.

What has been done in France (for an experimental period of six months) is to establish a series of zones around Orly and Le Bourget airports. The inner one, according to the magazine *Les Ailes*, extends from ground level to flight level 30 (3,000ft on 1,103mb) and is restricted to aircraft with radio arriving at or departing from Le Bourget, Orly, Villacoublay or Brétigny. Prior authorization is required from Paris control or from the tower of one of the airfields. The private fields of Chelles, Mitry-Mory and Enghien Moisselles have permanent authorization from Le Bourget to fly subject to certain conditions. La Ferté Alais will during weekdays have similar permanent authorization from Paris control and Brétigny; at weekends it is free because the zone is contracted while Brétigny is not active.

Around the central area is established an "upper reserved terminal area" extending to flight level 65. Lower levels are respectively 3,000ft at 24 miles, 2,500ft at 18 miles, and 1,300ft above mean sea level over an irregular area bounded by the arcs of 16-, 15- and 11-mile-radius circles based on Bourget and Orly (see map). In this area positive control is exercised, and all aircraft must have two-way radio.

Below the upper area is the "lower reserved terminal area" extending from ground level to the lower limits of the upper reservation. Within this airspace *airliners on IFR flight plans are prohibited*—the area is completely reserved for light aircraft. Presumably if a transport climbing out from either of the main Paris airports cannot make 1,300ft by the time that it is 18-25km from the runway, it must either be cleared through some other climb-out path, or take off at a lower weight. On the score of noise alone it seems undesirable for climb rates of only 200ft/min to be tolerated, and quite unreasonable that such poor performance should be allowed to impose such harsh restrictions on other users of the airspace.

Conclusions to be drawn from the foregoing seem obvious: if it is possible to modify zoning of the airspace in the United States and in France, it must surely also be possible here. The line of attack seems to be to adopt the transition zone, beneath which the airspace is free, and to reduce the size of control zones to more sensible proportions. Once this is done, special cases can all be considered, and zones and areas adjusted where, for example, special climb and descent path are required. Revision of the size and shape of control zones and control areas over the British Isles is long overdue. Such a good reason for change should surely not be ignored.

A. T. P.

SENSING TOTAL TEMPERATURE

ACCURATE measurement of total temperature (i.e., ambient temperature as raised by kinetic heating) involves a number of problems, but now available from a British source is a sensing unit designed to give precise results over a temperature range of −100°C to +350°C. Known as the Total Temperature Probe Type 102, it is being manufactured under licence by Research & Engineering Controls Ltd, of 9 Old Bridge Street, Kingston-on-Thames, Surrey (Kingston 6288), an associate company of the Rosemount Engineering Co of Minneapolis, USA.

The probe is stated to give fast and accurate measurement even when de-icing heat is applied, and to withstand extreme effects of vibration and shock. Special "open wire" elements for flight-test use have a time-constant of 0.02sec and a recovery error of less than 0.1 per cent of absolute temperature. The de-iced probes should have particularly useful application in civil and military aircraft under operational conditions, where they can provide information to assist in the selection of optimum engine settings for economy and safety. They can also help in the determination of true airspeed and in locating high-altitude jetstreams. The probe can, of course, be used either as a component of an air-data computer system or for a direct-reading temperature indicator; and, on the ground, it is of use in wind-tunnel instrumentation, particularly for research into icing.

The Type 102 temperature-sensing probe (shown approximately one-fourth actual size)

The Rosemount Company's probes are in use by airline operators and aircraft manufacturers, including Air France (for Boeing 707s), TCA (who have specified them for any future types they may operate), and Boeing, who, it is stated, will henceforth employ the equipment in all 707 variants.

Research & Engineering Controls, who have fulfilled a number of dollar-earning development and production orders for Rosemount, hold a licence to manufacture all the American company's products and to sell them in European markets. Apart from temperature probes, these products include compensated pitot/static tubes for aircraft flying at speeds of up to Mach 3; pressure transducers and altimeters; platinum resistor immersion probes for temperatures ranging from that of liquid helium to +1,500°F; and multi-point temperature monitoring and control equipment.

The American company is directed by Dr F. D. Werner, and the managing director of Research & Engineering Controls Ltd is Mr B. Rogal, BSC(ENG), AMIEE (until recently chief development engineer of Wayne Kerr Laboratories), with Mr R. W. Sutton (the well-known aeronautical consultant) and Mr J. G. Gallagher as fellow board-members.

Correspondence

The Editor of "Flight" is not necessarily in agreement with the views expressed by correspondents in these columns. Names and addresses of writers, not for publication in detail, must in all cases accompany letters.

JP.4 versus Kerosine

YEARS ago it was cheaper to send small children down mines, etc, *ad nauseam*. Some took advantage of it, others, in all probability the majority, reluctantly followed suit to remain economically competitive. A sigh of relief was probably heaved all round when—for example—the Factory Acts, the Plimsoll Line, etc, brought everyone back on an even keel to start again.

Unfortunately, capitalism is often its own worst enemy; hence the need and development of regulatory bodies. In the best of atmospheres they step in, in time; in the worst, new political systems are bred which result in the enslavement of all.

History repeats itself, for obvious reasons; the circumstances are the same. Liberty is precious, but the human race being what it is, there are always some who will abuse it; and sophistry, conscious or otherwise, always rises to the occasion.

It is cheaper in some places to buy JP.4; this fuel controversy is in principle analogous to the above. The patient believe that right will prevail in time. Others complain that the waiting period is too uncomfortable.

Today we have the regulatory bodies, so let them step in, and step in in time.

All they need do for gas-turbine-engined civil aircraft is to limit fuel flash point to 100°F minimum. Then it's kerosine, and at least the best has been done in the case of the survivable crash to postpone the everlasting bonfire.

London SW3 J. C. D. SOLTZ

London-New York: £30 Return?

IT seems that, as we are now virtually committed to entering the supersonic airliner "rat race", the prospect of very low fares in the near future has receded considerably. As I see it, BOAC are dependent for their traffic growth on the section of the population who can afford £100 to £300 fares, and this traffic growth will be the result of increased general prosperity rather than a lowering of fares. How much wiser it would be if the corporation introduced aircraft that could carry 150 passengers from London to New York for £30 return. Then we should see *real* traffic growth. Vast sections of the population would be able to afford fares of this order, and mass air travel would become a reality. Obviously, if BOAC operated such an aircraft, we would have to contract out of IATA unless it changed its hitherto inflexible position regarding fare differentials.

It is avoiding the issue to plead that the travelling public will always demand the fastest mode of transport available. The reason for this excuse has been the comparatively small differentials at present operative between pure-jet and propeller-driven aircraft. But if a modern turboprop or turbojet with a subsonic cruising speed could provide transport to the Americas at a cost in the region of £30 return, the great majority of passengers would not be prepared to pay a surcharge of £100 just to get there six hours earlier. I believe that this factor has been seriously neglected by our civil air transport policy-makers, and the loser is, as always, the public.

The huge cost of supersonic airliner development is bound to be reflected in the fares charged, and these must inevitably be of a high nature. To my mind, the money would be better spent in developing VLF to the ultimate, technological advancements being used to *reduce* fares instead of indulging in expensive speed competitions with other nations. From the guarded and unenthusiastic statements issued by BOAC and the Ministry of Aviation, it would seem that we are being drawn into the supersonic age rather unwillingly, and we are apprehensive of matching VLF with VHS (very high speeds).

London, NW11. C. F. SCOTT

Noblesse Oblige

I WOULD like to ask Geoffrey Dorman if Cody was a colonel —commissioned, honorary or any other type—at the time he tethered his horse, dog, aeroplane or what have you to that synthetic tree.

A similar story is told of "Lord" George Sanger and Queen Victoria, but this did not entitle Sanger to a seat in the Upper House.

One wonders what would happen should the reigning monarch meet Duke Ellington or Prince Littler.

London W1 HERR SPLITTER

Handley Page Transports

I WAS interested to read the article by Peter W. Brooks (*Flight*, January 13) on *The First Handley Page Transports*. I particularly refer to the second and third paragraphs which mentioned the conversion of two 0/400s for the transport of ferry pilots. For Mr Brooks' records I enclose two snapshots [one of which is reproduced herewith. — Ed] showing the crude seating arrangements in one of these 0/400s. As I did not see any reference to the fact that these aircraft had folding wings, I also enclose a snapshot which illustrates one of them with wings folded.

Leeds 2, Yorks ARNOLD G. WILSON
(owner of Gemini G-AMDE)

Renfrew Replacement

IN your issue of February 3 Mr Gall puts forward the claims of Edinburgh (Turnhouse Airport) as Renfrew Airport's replacement, but is literally wandering away from the subject. Despite his aversion to references to distance and time, these are nevertheless factors which cannot be completely ignored; and it is most unlikely that Glasgow business circles and BEAC, who have objected to travelling 29 miles to Prestwick, would be favourably disposed to the 40-odd-mile journey to Turnhouse Airport. Neither would its use offer the very desirable integration of short- and long-haul routes for which Prestwick is, at this moment, technically equipped.

If I may be permitted to digress to the question of lack of direct Continental routes from Glasgow and Edinburgh to which Mr Gall referred, Scotland to some small extent has herself to blame for this. In most other countries the international airport is the focus of development and becomes the hub of international routes distributing to other parts of the country the benefit of its position on the world's air routes. In Scotland many areas use internal services to London as connections to foreign destinations, thus by-passing existing European and long-distance links at Prestwick. It is, of course, true that until now there have been no proper feeder services to Prestwick, but this is being rectified and it is to be hoped that Scotland will support the efforts being made in this direction by Ayr County Council, otherwise continued support of connections via London will in my opinion only further delay the day when other centres in Scotland will get direct Continental links.

Ayr DAVID REID

Beagle Variants

ROGER BACON'S list of forthcoming Beagle Eagle variants (*Flight*, February 10) was sadly incomplete. Servicemen everywhere will mourn the omission of the Pay Accounts version, the celebrated Golden Eagle, whose peculiar pecuniary habits we all loved so well.

Leighton Buzzard, Beds G. C. STUBBS

FORTHCOMING EVENTS

Mar 1. London Society of Air-Britain: Film Show.
Mar 1. RAeS Graduates' and Students' Section: Annual General Meeting.
Mar 1. Society of Instrument Technology (South Yorkshire Section): "High-speed Instruments for Combustion Research," by A. E. Pengelly.
Mar 3. RAeS Rotorcraft Section: "Helicopter Approach Aids," by H. W. Mitchell and S. G. Lennox.
Mar 8. RAeS (main lecture at Chester Branch): "Low-speed Problems of High-speed Aircraft," by A. Spence and D. Lean.
Mar 8. Kronfeld Club: Photographic Exhibition, and talk by F. N. Slingsby.
Mar 9. Radar and Electronics Association: "Air Traffic Control," by Arnold Field.
Mar 10. British Gliding Association: Annual Ball.
Mar 11. British Gliding Association: Annual General Meeting.
Mar 13. RAeS Historical Group: "Evolution of Transport Aircraft," by Peter W. Brooks.
Mar 15. Kronfeld Club: "Collision Experiments with Wire Barrage Weapons," by Gp Capt Kent.
Mar 16. RAeS Astronautics and Guided Flight Section: Symposium on "Training of Guided-missiles Engineers."
Mar 17. RAeS Man-powered Aircraft Group: "Power Transmission Systems," by S. S. Wilson.

RAeS Branch Fixtures (to Mar 3): Feb. 27, *Henlow*, Film Evening. Feb 28, *Boscombe Down*, "Yacht Performance Analysis," by P. Crew. Mar 1, *Preston*, "New Ideas in Aircraft Electrical Systems," by M. Hancock.

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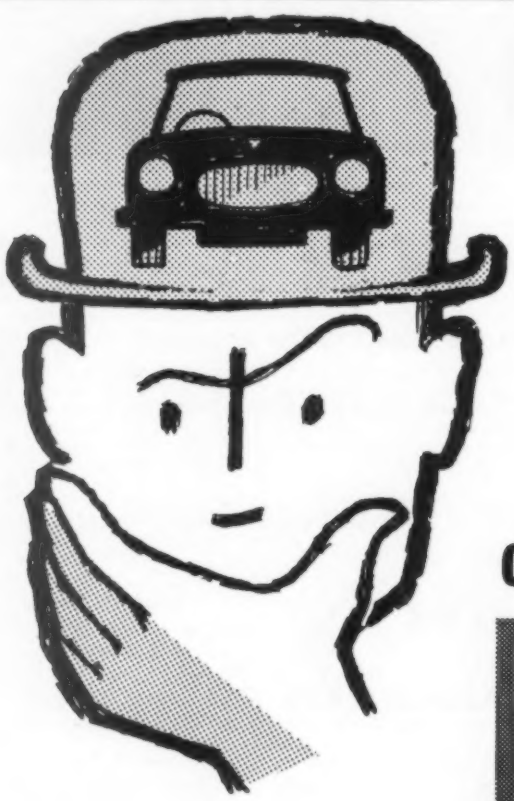

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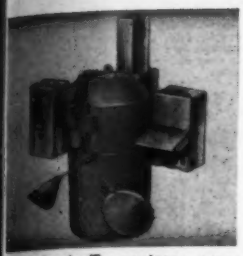

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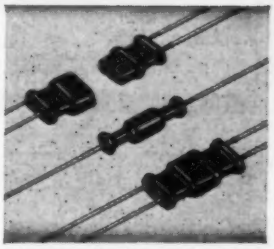

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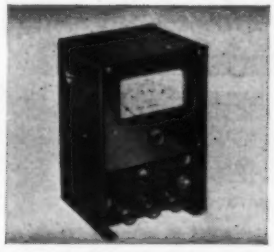

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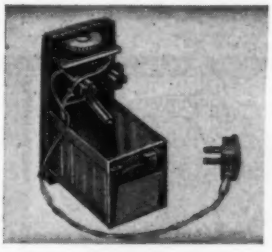

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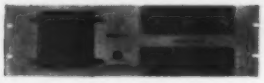

PLAYBACK UNIT
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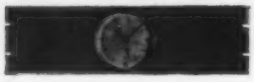

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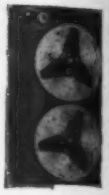

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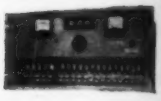

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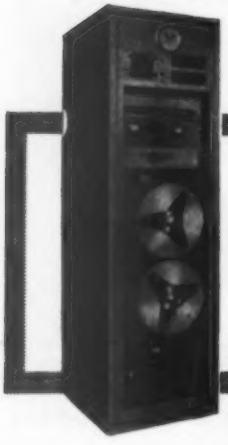

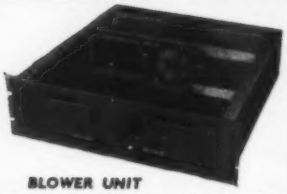

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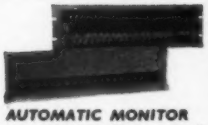

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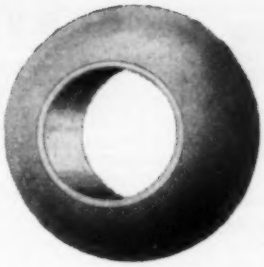

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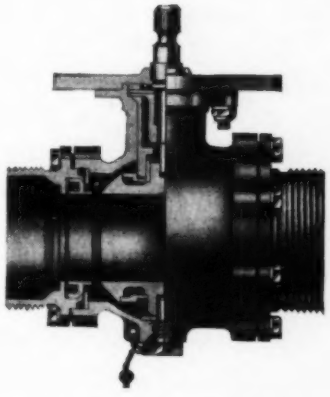

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INDEX TO ADVERTISERS

	Page
Aero-Enterprises (Boreham Wood) Ltd.	38
Aeronautical and Marine Supplies Ltd.	37
Airmed Ltd.	28
Airwork Services Ltd.	30, 41
"Amateur Photographer"	16
Associated Electrical Industries Ltd.	17
Atlantic Aviation Corporation	38
"Autocar, The"	32
Bendix Corporation, The	cover ii, 1
Benson (A.I.F.) Ltd., J. J.	38
Blackburn Aircraft Ltd.	29
Boulton Paul Aircraft Ltd.	11
British Airline Pilots Association, The	39
British European Airways	12, 41
British Overseas Airways Corporation	40
British Refrasil Co. Ltd.,	16
B.S.T. Aeronautical Co. Ltd.	38
Burndept Ltd.	6
Canadian Marconi Company	15
Civil Service Commission	40
Cossor Radar and Electronics Ltd.	26
Congea Nouvelle	38
Crook Motors Ltd., Anthony	38
Cross Manufacturing Co. (1938) Ltd.	38, 39
Decca Navigator Co. Ltd., The	27
Decca Radar Ltd.	5
De Havilland Aircraft Co. Ltd., The	35
'Diamond H' Switches Ltd.	32
Dunlop Rubber Co. Ltd.	cover iii
Elliott Brothers (London) Ltd.	14, 22, 33
Ferranti Ltd.	9
Firestone Tyres and Rubber Co. Ltd.	7
Firth and John Brown Ltd., Thos.	8
Harleyford Publications Ltd.	34
Hawker Siddeley Aviation Ltd.	18
Helicopter Services Ltd.	38
Hodder and Stoughton Ltd.	30
"International Plastics Engineering"	10
Lockheed Precision Products Ltd.	cover iv
Marconi's Wireless Telegraph Co. Ltd.	31
Marshall's Flying School Ltd.	38, 39, 41
Miller Aviation Ltd.	42
Ministry of Aviation	41
Newmark Ltd., Louis	20
Normalair Ltd.	13
Orchard and Ind. Ltd.	28
Overseas Aviation Ltd.	38
Parker (Aircraft Spares) Ltd., W. A.	
Phillips and White Ltd.	
Putnam and Co. Ltd.	
Ratcliffe (Rochdale) Ltd., F. S.	
Rists Wires and Cables Ltd.	
Rotax Ltd.	
Saunders Valve Co. Ltd.	
Scottish Aviation Ltd.	
Shackleton (Aviation) Ltd., W. S.	
Short Bros. and Harland Ltd.	cover i,
Smart and Brown Machine Tools Ltd.	
Smiths Aircraft Instruments Ltd.	
Standard Telephones and Cables Ltd.	
Thermionic Products (Electronics) Ltd.	
Triplex Safety Glass Co. Ltd.	
United Dominions Trust Ltd.	
Vigors Aviation Ltd.	
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Whiteley Electrical Radio Co. Ltd.	
Whittemore and Sons, A. J.	

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